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MORPHOLOGY AND CLASSIFICATION OF THE PHILIPPINE VARIETY OF ANOPHELES ACONITUS DONITZ, 1902, AND ANOPHELES MINIMUS THEOBALD, 1901 [1]

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ONE PLATE

Banks[2] included among Philippine Culicidæ *Anopheles funestus* Giles, 1900, and *A. minimus* Theobald, 1901, both collected by Capt. E. R. Whitmore in Camp Stotsenberg, Pampanga, and a species, *A. mangyana* Banks, 1906, collected by R. C. McGregor from Rio Baco, Mindoro. Bezzi [3] included "*Myzomyia rossi mangyana* Banks, 1906" and "*Myzomyia funestus* Giles, 1900" in his list of anophelines. *Anopheles febrifer* Banks,[4] with which Walker and Barber [5] obtained a high infection rate when it was artificially fed on gamete carriers, was obtained from Canlubang, Laguna. Christophers [6] lists *A. febrifera*, *A. mangyana*, and *A. flavirostris* Ludlow, all of Philippine origin, as synonyms of *A. minimus*. *Anopheles flavirostris* came from Camp Wilhelm, Tayabas, and was previously referred to by

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[2] Philip. Journ. Sci. 1 (1906) 977.

[3] Philip. Journ. Sci. § D 8 (1913) 305.

[4] Philip. Journ. Sci. § D 9 (1914) 405.

[5] Philip. Journ. Sci. § B 9 (1914) 381–439.

[6] Ind. Med. Res. Memoir No. 3 (1924) 50.

Miss Ludlow as *A. funestus*, dark variety.[7] Tiedeman,[8] in his discussion on Philippine anophelines, page 226, said: "Dyar, Christophers and Root have each very kindly identified specimens sent them. It is of particular interest to note that the *A. febrifer* Banks with which Walker and Barber worked is *A. minimus*." Baisas[9] described *A. minimus* Theobald (typical) and three varieties of this species, all with branched (frayed) anterior inner clypeal hairs, which differed from each other according to the form (with or without branching) of the anterior external clypeal and the preantennal (posterior clypeal) hairs, but made no mention of *A. aconitus* Donitz, 1902. In the same paper, page 269, he gave an opinion of Root[10] based on a number of adults bred out from both the simple and branched-haired Philippine larvæ, sent to him by Mr. Mieldazis, of the Rockefeller Foundation. Root placed all Philippine *A. minimus* with branching of one kind or another of the clypeal and preantennal hairs under *A. funestus* var. *aconitus* and those without branches (except sometimes for slight apical bifurcation in the inner anterior clypeal and preantennal hair—Baisas) under *A. funestus* var. *minimus*.

From this brief review of the literature on the local *funestus* group, only Root (by reason of ample material examined and accurate information on the larvæ from which they were bred out by Baisas, two males with five females from typical and eight males with twelve females from atypical larvæ) considered the presence of a variety of *aconitus*[11] in the Philippines. He said, however:

> In order to do this latter [meaning creating a *funestus* var. *aconitus*], it would be necessary to amend the definition of variety *aconitus* so as to make[12] three dark spots on the 6th vein of the female and fringe spot at its

[7] Cited from Christophers, p. 50.

[8] Journ. Prev. Med. 1 (1927) 205–254.

[9] Monthly Bull. Phil. Health Service 7 (1927) 267–280.

[10] Personal communication to Dr. V. G. Heiser, of the Rockefeller Foundation, in 1926, a copy of which was kindly furnished me by Mr. J. J. Mieldazis.

[11] Baisas's record shows that these larvæ were collected from Pabanlag (Del Carmen, Pampanga) irrigation ditch in the middle of rice paddies. Water, slow flowing, and ditch full of grass, rather typical for this species in Java.

[12] The present series shows just over one-half of the females with three spots on the sixth vein (19 of 34, or 56 per cent) and 76 per cent with fringe spot at its tip.

tip, the main diagnostic characteristics of this variety with the apical golden half of the proboscis a variable character.

Records of routine dissections in the malaria-control laboratory of the Philippine Health Service of over 50,000 anophelines from malarious stations during the past two years, attribute all stomach and salivary-gland infections to *A. minimus* (excepting a heavily infected stomach of *A. vagus* Donitz, out of over 10,000 dissections of this species) omitting entirely *A. aconitus*, based on Baisas's opinion that the frayed-haired larvæ which Root considered *A. funestus* var. *aconitus*, were varieties of *minimus*. Furthermore, Root's ruling was not followed, due to the constantly black proboscis of the local *aconitus* and the frequently denuded wings [13] of the mosquitoes which made its differentiation from *minimus* difficult. In our past records of larval collections during surveys, or from streams in Paris green control areas, the typical and varieties of *minimus* were also entered under one name.

Anopheles minimus with malaria and *A. minimus* without it, in adjacent or similar localities with apparently all the existing conditions favorable for the propagation of the disease in both, were not infrequent in our past surveys, and this has not been clearly explained. Our failure to differentiate the local variety of *A. aconitus* from *A. minimus* may be one of the reasons. The data on hand on the incidence of *aconitus* among the supposed *minimus* larvæ collected from different stations are meager, but they vary from 0 to 30 per cent. The local and general importance of the systematic position of this group of Philippine mosquitoes is apparent, hence the present morphologic study.

I am indebted to Mr. C. M. Urbino, of the malaria-control division, Philippine Health Service, for the care he took in collecting the material during April, May, and June, 1929, mostly from Bulutong stream about 200 meters east of the laboratory at Tungkong Manga, Bulacan. The larval skins after pupation, which were originally preserved in alcohol, were permanently mounted on slides with Berlese's fluid. The adult mosquitoes, which carried the serial numbers of their respective skins, were pasted with shellac solution on cardboard wedges. Of the 241 larval skins examined, 73 skins, or 30 per cent, had frayed an-

[13] The specimens had to be transported by automobile on bad roads from stations 10 to 33 kilometers from the laboratory. It is hoped that the recent transfer of the laboratory to the field will help matters much.

terior internal clypeal hairs (*A. aconitus*); the remaining 168 had simple hairs. For morphologic correlation 65 skins of *A. aconitus*, 155 skins of *A. minimus*, and their corresponding adults were used, with 37 per cent of the former and 39 per cent of the latter, males. Of the females, 34 *aconitus* and 65 *minimus* were compared.

TABLE 1.—*Showing comparative morphology of the larval skins of Anopheles aconitus and A. minimus.*

Anatomical structures.	*A. aconitus.*		*A. minimus.*	
	Skins examined.	Number and per cent.	Skins examined.	Number and per cent.
Anterior internal clypeal hairs	73		168	
With simple hairs		0		168
Do per cent		0		100
With frayed hairs		73		0
Do per cent		100		0
Anterior external clypeal hairs	30		36	
With simple hairs		20		33
Do per cent		67		92
With forked hairs		10		3
Do per cent		33		8
Posterior clypeal hairs	63		114	
With simple hairs		4		107
Do per cent		6		94
With forked hairs		59		7
Do per cent		94		6
Chitinous islets	72		133	
With islets		70		2
Do per cent		97		2
Without islets		2		131
Do per cent		3		98
Occipito-clypeal pattern	32		51	
With O-shaped pattern		29		8
Do per cent		90		16
With U-shaped pattern		3		43
Do per cent		10		84

LARVÆ

1. For convenience, all larvæ of this series with frayed or branched anterior internal clypeal hairs are classified as *A. aconitus*. In skin 637, included in the table, these hairs are distinctly branched.[14] Those with simple anterior internal clypeal

[14] An adult male with interrupted basal costa, no pale fringe at the tip of sixth vein and two spots on sixth and basal spot on third vein, was bred from the specimen.

hairs are classified *minimus*. No apical bifurcation of this hair as noted by Baisas was seen in the series. It may be stated that Strickland's [15] description of the larva of *minimus* gives this hair as being simple (p. 150), but his Plate 11, fig. 9, *a*, depicts apical bifurcation in both hairs.

2. Bifurcations, either apical or basal, of the anterior external clypeal hairs of *aconitus* are usually unilateral, but those with three or more branches are bilateral. In the larval skins examined the mouth brushes are always extended and obliterate these hairs. To expose them the occipital chitinous plate, which is usually disarticulated, is separated from the head, placed ventral side up, and with care and fine-pointed needles the brushes can easily be detached, leaving the anterior external clypeal hairs attached to the clypeus in most cases. Should they fall off, their recognition even if simple is not difficult, if care is taken that they be not confused with a pair of simple but bent, stout lip hairs located ventrally and anterior to the anterior internal clypeal hairs.

3. Branching of the posterior clypeal hairs of *aconitus* which is bilateral (more frequently with three or four branches than two) has been found to be just as important diagnostically as the simple hair (excepting rare unilateral bifurcation) in *minimus*.

4. By "chitinous islets" (Plate 1, fig. 1) is meant the pair of tiny elliptical (sometimes slit-shaped when on edge) dark brown to black plates of chitin in the integument of the dorsum of the first seven abdominal segments of *aconitus* larvæ (in some specimens they are not visible in the first three segments when the tergal plates are poorly developed). They are best seen on a dorsoventral position of adult living or mounted larvæ, posterior to the tergal plates, one on each side of the median line, forming a triangle with the dark pigmented area in the middle of the plate [16] (except the eighth). Because of the transparency of the colorless larval skin surrounding them, they appear like pairs of minute chitinous "islands." In skins they are even more distinctly visible than in larvæ, but due to telescoping of the segments they frequently appear to be in the tergal plates themselves. They are always darker than the area on the plate. They measure about 10 μ by 40 μ (longest diameter transverse), and under a high power show the same laminations that are

[15] Ind. Journ. Med. Res. 12 (1924) 145–152.

[16] Like the holes for the eyes and nose of a Hollowe'en pumpkin.

seen on the edge of the tergal plates. As far as I can find out, these structures have never been described before in *aconitus* larvæ; although Strickland's plate 12, a microphotograph of an *aconitus* larval skin, shows them quite clearly in segments 4, 5, and 7. They seem to show a certain difference in the degree of chitinization between the two species. The few exceptions in which they are not seen in *aconitus* are in skins where the general chitinous frame is pale and appears thin. Conversely, the two exceptions in *minimus* show marked development of their chitins.[17] The material examined shows these "chitinous islets" to be important structures in differentiating Philippine *aconitus* and *minimus* larvæ, fig. 2, and larval skins, even when the head capsule is missing.

5. When the occipital chitinous plate is separated from the head, pigmented areas are revealed which are arranged in a more or less definite "occipito-clypeal pattern" and which, as far as the material examined is concerned, also show a fairly constant difference between *aconitus* and *minimus*, figs. 3 and 4; the former giving an O-shaped and the latter a U-shaped pigmented area in the anterior half of the pattern. In some instances (10 per cent) a lightly pigmented *aconitus* shows a U and conversely a deeply pigmented *minimus* an O or Θ pattern (16 per cent). Apparently, this larval character has also been overlooked before, although it may be of some value in closely allied species.

6. The frequent loss of the internal occipital (transutural) hairs precludes the examination of a good number in the present series, but examination of many larvæ shows a constant difference in their branching; *aconitus* with simple, relatively long, basal branching of three or four, while *minimus*, with basal bifurcation into two main trunks, which later give off two to five short branches each.

7. The antepalmate hairs on the second abdominal segment show, as a rule, apical branching in *aconitus* and basal in *minimus*.[18] This hair is often misplaced or lost in mounting larval skins. They are better seen on larvæ mounted in Gater's fluid.

[17] The absence of "chitinous islets" in a very small number of *aconitus* and their presence in a similar number of *minimus* may be a manifestation of the result of interbreeding between the two. The same may be true with other larval structures and the markings in the adult.

[18] Mr. F. E. Baisas has kindly called my attention to this important difference.

8. The posterior border of the second, and frequently the third, tergal plate in *minimus* is always concave or indented while in *aconitus* it is convex.*

TABLE 2.—*Showing comparative morphology of the adults of Anopheles aconitus and A. minimus.*

Anatomical structures.	*A. aconitus.*		*A. minimus.*	
	Mosquitoes examined.	Number and per cent.	Mosquitoes examined.	Number and per cent.
Proboscis ♀ (distal half)	34		65	
With black distal half		34		50
Do per cent		100		77
With slightly flavescent distal half		0		15
Do per cent		0		23
Palps ♀ (the two apical white bands)	34		65	
With bands equally wide		18		62
Do per cent		53		95
With distal band wider		16		3
Do per cent		47		5
Costa ♂ and ♀ (basal or proximal third)	62		153	
With interrupted proximal third		54		79
Do per cent		87		52
With proximal third all black		8		74
Do per cent		13		48
Fringe ♂ and ♀ (pale spot at apex of sixth vein)	63		152	
With pale spot		42		11
Do per cent		67		8
Without pale spot		21		141
Do per cent		33		92
Third longitudinal vein ♂ and ♀ (basal spot) [a]	64		155	
With basal spot		46		144
Do per cent		72		93
Without basal spot		10		3
Do per cent		15		2
Sixth longitudinal vein ♂ and ♀ (No. black spots)	65		155	
With two spots		38		122
Do per cent		58		80
With three spots		23		6
Do per cent		35		4

[a] The basal black spot, as a rule, is longer and darker in *minimus*.

ADULT

1. The proboscis of the present series is all black in *aconitus*, and 23 per cent slightly flavescent distal half in *minimus*, usually laterally and inferiorly.

2. In about 50 per cent of *aconitus* the two broad apical white bands of the palps are equal in width, the intermediate black

* An observation by Mr. A. G. Laurel. In the case of the two *minimus* with "chitinous islets" their second tergal plates showed this indentation.

band very narrow. In the others the terminal white is slightly broader. The intermediate black is as wide or even wider than the second white in a number of them. In *minimus* these bands (two apical white) are usually equal. The apical black band and proximal white in *aconitus* are more frequently wider than those in *minimus*. The apical black band is frequently pale brown to gray in *aconitus*, but as a rule it is black in *minimus*. Specimen 307 of *aconitus* shows no apical black band at all.

3. In 31, or 91 per cent, of 34 female *aconitus* the base of the costa is interrupted; in 28, or 43 per cent, of 65 female *minimus* the base is interrupted. In about 20 per cent of *aconitus* with interrupted basal third of the costa, two pale spots caused the interruption, a condition not observed in *minimus*.

4. The pale spot on the fringe at the tip of the sixth vein is present in 67 per cent of *aconitus*, (male and female), and only 8 per cent of *minimus* (male and female). This spot is often difficult to see in the males. Among 34 female *aconitus* the spot is clear in 26, or 76 per cent; and of the 65 female *minimus*, it is clear in 9, or 14 per cent.

TABLE 3.—*Important differential characters of female Anopheles aconitus and A. minimus, wings only.*

Anatomical structures.	*A. aconitus.*		*A. minimus.*	
	Mosquitoes examined.	Number and per cent.	Mosquitoes examined.	Number and per cent.
Costa (basal or proximal third)	34		65	
With interruption		31		28
Do per cent		91		43
Without interruption		3		37
Do per cent		9		57
Fringe (pale spot at apex of 6th vein)	34		65	
With pale spot		26		9
Do per cent		76		14
Without pale spot		8		56
Do per cent		24		86
Sixth vein (number of black spots)	34		65	
With three spots		19		4
Do per cent		56		6
With two spots		15		61
Do per cent		44		94

5. No marked difference is noted in the amount of white area in the third vein of both species although the tendency is longer white in *aconitus*. Neither is the difference in the incidence of the dark basal spot in both species significant, 72 per cent for

aconitus (male and female) and 93 per cent for *minimus* (male and female). Four specimens with all white and eight with basal spots only are recorded in the *aconitus* series, and three all white and eight with basal spots only in *minimus*. The basal spot of *minimus* is usually darker and often longer than that of *aconitus*. In a few instances there are noted two dark basal spots in the third vein of *minimus* but none in *aconitus*.

6. The difference in the number of black spots on the sixth vein of both species is significant. In female *aconitus*, 56 per cent had three spots and 44 per cent two spots. Of 65 female *minimus*, 61, or 94 per cent, had two spots. In both species, when two spots are present, the apical (distal) occupies about all of the apical half of the vein. In about 7 per cent of *aconitus* and 16 per cent of *minimus*, the two spots on this vein are confluent or almost so, and more often in males than in females.

7. The anterior branch of the fifth vein in six specimens among one hundred fifty-five adult *minimus* is mostly black; that is, the middle black spot is continuous with the apical one. They are all without the pale fringe spot at the tip of the sixth vein, three are with interruption at the base of the costa and three without.

8. There is no difference noted between the two species in the buccopharyngeal armatures of the females or the male genitalia.

COMMENTS

Strickland suggested a standard practice (p. 152) giving distinct anophelines varietal rank if their larvæ are identical, and specific rank if their larvæ are different. After a careful consideration of their larval and adult characters, he sank *minimus* under *funestus* but maintained *aconitus* as a distinct species.

Root's [19] stand on the Philippine *funestus* group has already been given. This author [20] (1926) gave the following opinion (p. 68) in his studies on South American anophelines:

> I have taken the position that where well marked and constant differences existed in larval structure and male genitalia, it was proper to consider the two forms distinct species, even though no satisfactory characters for the separation of the adult females could be presented. This is my reason for describing *A. strodei* as a new species. Conversely, in the case of *A. braziliensis*, where the male genitalia and larvae are identical or practically so, I have considered the small, but definite differences in adult markings as deserving a varietal status.

[19] Root's stand was not offered as an authoritative ruling, but only an idea of the most satisfactory classification.

[20] Am. Journ. Hyg. 6 (1926) 684–717.

Carter [21] (1924) agreed with Strickland (p. 33) in the identity of *Anopheles minimus* and *A. funestus listoni* but retained *aconitus* as a variety of *funestus* due to the occurrence in Ceylon of an "intermediate form" of larva between *funestus* and *aconitus*. He said (p. 48) that this form is the commonest in Ceylon and the clypeal and preantennal hairs usually all possess a few short branches arising at intervals along the stem. In his synopsis (p. 55) he included the "intermediate form" with the typical (simple-haired) *funestus* var. *listoni*. For *funestus* var. *aconitus* he gave "inner and outer clypeal hairs with more numerous short branches, preantennal hair branched (5 to 6 divisions) from the base." In his description of the adult (pp. 33–34) Carter did not mention what sort of an adult emerged from the "intermediate form" of larva, but I take it as identical with adult *funestus listoni*. Carter also failed to mention whether or not the adults he described were bred out from larvæ whose skins after pupation were used in his larval description.

An application of Strickland's "standard practice" and Root's opinion to Carter's Ceylon material will necessarily give rise to two identical adult mosquitoes with different names, *A. funestus listoni* and a new name for the "intermediate form" following the former author; and two different adult mosquitoes, *funestus* var. *aconitus* (larva with branched clypeal hairs) and *funestus listoni* (larva with simple clypeal hairs) identical following the latter. The puzzle may be solved by both Strickland and Root, either hoping that an unavoidable accident crept in Carter's manipulation of his material whereby an "intermediate form" adult was credited to a typical *listoni* larva, or conclude that the Ceylon "intermediate form" is not *listoni* but a variety of *aconitus* something like the one in the Philippines with the proboscis all black, etc., and not readily distinguishable from adult *listoni*. If Carter's observation was correct, Strickland and Root will have to reconsider their stand. I am inclined, however, to agree with the majority. As for the status of the Philippine species, the following considerations will determine.

1. Christophers and Carter define female *aconitus* as (1) distal half of proboscis always golden; (2) vein 6 with three dark spots; (3) fringe spot at vein 6; (4) vein 3 extremely pale, usually without dark spot towards base; (5) base of costa with about

[21] Ceylon Journ. Sci. § D 1 (1924) 29–59.

equal frequency with or without a pale interruption. Swellengreble [22] described in a series from Mandailing, Java, what he considered to be atypical *aconitus* with its proboscis all black; palp with two terminal white and intermediate black bands equally broad; base of third vein pale; sixth vein with two black spots and no pale fringe spot at its tip. Strickland, however, (p. 148) believed them to be, "a series of *minimus* with only one character, either the palps or the 3rd vein atypical and all other characters typical rather than *aconitus* with only one character, the 3rd vein typical and all other characters atypical." Strickland did not mention if the larva of Swellengreble's atypical *aconitus* were known, but I take it that it should have the *minimus* type of anterior internal clypeal hairs to make his standard practice consistent with his conclusion on the adult. Reference is not available if Swellengreble reared his adults from known larvæ or not. In their [23] article on larvæ, they described *A. aconitus* Donitz (p. 28) and a variety (p. 29), the latter (from Penjaboengan, Mandailing) having completely bald (not frayed) clypeal hairs (pl. 13, fig. 1). If Swellengreble's atypical adult came from the "bald" type of larva, Strickland's conclusion was right and Swellengreble's variety of *aconitus* larva must surely have been *minimus*.[24]

In the adult findings on the local *aconitus*, a certain percentage of them agreed with Swellengreble's mosquitoes (be they his atypical *aconitus* or typical *minimus*); namely, the black proboscis; basal spot of third vein absent in 15 per cent; 44 per cent with two dark spots on sixth vein and 24 per cent without pale fringe spots at its tip. Following Strickland's and Christophers's description of female palps typical of *aconitus* (two broad pale apical bands) the female palps of the local mosquito show 53 per cent agreement; vein 6 with three dark spots in 56 per cent; pale fringe spot opposite sixth vein in 76

[22] Cited from Strickland.

[23] Mededeelingen van Den Burgerlijken Geneeskundigen Dienst in Nederlandsch-Indie, Deel VI (1919).

[24] The more so when they said (p. 29), "the larva of M. minima comes quite close to this form but the filaments of the leaflets of the fans (palmate) are longer in the latter." Under Myzomiya minima (p. 30) they said: "In all particulars perfectly similar to the variety of M. aconita. The only difference to be detected is the length of the filaments of the leaflets of the abd. fans which is ½–⅗ of the length of the leaflet, whereas in aconita (variety) it is only ⅗, ⅔ at the utmost of this length. I am not sure whether this distinction always holds true."

per cent; third vein without basal black spot in 15 per cent; and base of costa interrupted in 91 per cent (uninterrupted, p. 148—Strickland). It is evident, therefore, that the principal departures of the Philippine *aconitus* from the classical definition of this species are the black proboscis and the dark spot (75 per cent) at the base of the third vein.

The larva of the local variety with fraying of anterior internal clypeal hairs agrees with Strickland's from Malaya and Assam, excepting in the anterior external clypeal which is forked or simple in the present series but frayed with this author. Our *aconitus* differs from the Javanese (p. 28) in the same way that Malayan and Assamese did. Ceylon *aconitus*, according to Carter, has definitely branched clypeal and preantennal hairs. All the other larval structures, however, in specimens from Assam, Malaya, Java, or Ceylon agree with those in Philippine specimens. Branched hairs in Ceylon and frayed in Malaya, Assam, and Java, giving rise to the same mosquito, is interesting to note. I have observed few larvæ with definite branching and 1 in 65 of the present series with, so far, no difference in the adult character. It looks as if in this group of mosquitoes, it is the presence or absence and not the branching, fraying, or its amount that counts.

ANOPHELES ACONITUS var. FILIPINÆ var. nov.

In conclusion, the local female adult *aconitus* has been shown to have characters in common with varying frequencies with the typical forms from Assam, Malaya, and Ceylon. The larvæ have also been shown to have most of the principal characters excepting the type of branching of the clypeal hairs. Therefore, it seems proper to accept Strickland's stand and Root's opinion that there is present in the Philippines a variety of *aconitus* whose larva is identical with the typical (with minor variations in the clypeal hair branching), but the adults of which manifest definite variations (black proboscis, etc.) from *aconitus* Donitz. Therefore, I propose to call the local mosquito *Anopheles aconitus* var. *filipinæ* var. nov. and not *funestus* var. *aconitus* Root. The female of this variety has the following outstanding characters: (*a*) Black proboscis; (*b*) costal interruption at basal third (when there are two interruptions it is surely *aconitus*); (*c*) pale fringe spot opposite the sixth vein; (*d*) sixth vein with two or three dark spots.

2. Strickland reduced *minimus* to *funestus* after showing by careful analysis of the female adult characters that the defini-

tions of *minimus* and *funestus* by Christophers, Edwards, and Ingram were inadequate,[25] their male genitalia identical (pp. 150–151) and because he could show that their larvæ and pupæ were also identical. The West African *funestus* he examined was furnished him by Scott-Macfie and Ingram (p. 150), while his *minimus* larvæ were from Assam. Strickland's description of *minimus* (*funestus*) larvæ tallies with the characters of larvæ from the Philippines. The adult characters of the local *minimus* also agree with Strickland's definition of *funestus* except the occasional pale fringe spot (14 per cent) at tip of sixth vein in the local female [26] *minimus*, but never found in his. It is but logical to concur with him, and that the Philippine *minimus* [27] should be called *A. funestus* (Giles, 1900) emended by Strickland, 1924, and not *funestus* var. *minimus* as suggested by Root. I have arrived at my present conclusions in complete agreement with Strickland (pp. 151–152),

> that the ontogeny of mosquitoes as of any other creatures betrays their phylogeny seems to be often ignored by systematists. Carter (in Byam and Archibald) for instance, in his schedule of anopheline species has relegated to a footnote the species *novumbrosus* and *similis* unworthy companions to the *haute elite* of the family, on the ground that the former are *mainly determined by larval structure.* This seems to me a sufficient reason for giving them more definite status than any species based on only adult characters and the feeling is born out by Christophers' recent discovery which he kindly allows me to mention that *novumbrosus* as determined by the male genitalia is very remarkably distinct.

For differential characters in the wings of the local female *aconitus* and *minimus* (*funestus*), see Table 3.

A restudy of the *funestus-aconitus* group (or any other similarly allied groups of mosquitoes) as they occur in different countries with the practice of using only those adults whose original larval skins are preserved and described will be the only means of avoiding confusion and defining criteria for their

[25] Strickland, page 149, said that in addition to his own Assam *minimus*, he studied *funestus* and *minimus* from Sierra Leone, the Gold Coast, Zanzibar, and Western India. The specimens were furnished by Christophers and by Scott-Macfie and Ingram.

[26] Nine of 65 females had distinct pale spots. Although the chance of error in numbering and mounting is small, I do not ignore its possibility.

[27] J. A. Sinton (July 30, 1928) writes me in agreeing with our identification of *A. minimus* Theobald, on specimens sent to him, that the absence of interruption on the inner quarter of the costa, as described in typical minimus, makes them resemble Iyengar's *varuna.*

varietal or specific rank. I failed to notice any mention of this procedure in Carter's work, and in Iyengar's [28] on *A. varuna* Iyengar, 1924 (*A. minimus* var. *varuna* Christophers, 1924).

It is hoped to extend the present study, particularly on materials from different localities, in order to confirm or amend the present conclusions. Pending further observations to show the contrary, all frayed or branched Philippine larvæ heretofore called *minimus* varieties should hereafter be called an *aconitus* variety.

SUMMARY

1. A brief review of the literature on the Philippine *A. funestus* group and rulings on the nomenclature are given.

2. Morphologic study of a series of adult mosquitoes of this group and the larval skins from which they were bred out is presented and discussed.

3. A consideration of the principal characters of the local mosquitoes and those described from Ceylon, Assam, Java, and Malaya shows that there exists a variety of *aconitus* (*filipinæ* var. nov.) in the Philippines which has heretofore been classified as varieties of *A. minimus* Theobald. The opinion is also expressed that the local *minimus* is identical with *A. funestus* (Giles, 1900) emended by Strickland, 1924.

[28] Ind. Journ. Med. Res. 12 (1924) 23–29.

ILLUSTRATIONS

[Microphotographs for figs. 1 and 2 by the Philippine Health Service; for figs. 3 and 4, by the Bureau of Science.]

PLATE 1

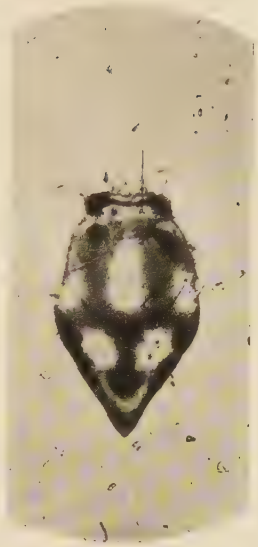
FIG. 1. Larval skin of *Anopheles aconitus* var. *filipinæ* showing the "chitinous islets."

2. Larval skin of the Philippine *Anopheles funestus* without the "chitinous islets."

3. "Occipito-clypeal pattern" of *Anopheles aconitus* showing an O-shaped pigmented area.

4. "Occipito-clypeal pattern" of *Anopheles funestus* showing a U-shaped pigmented area.

1



3

2

4

PLATE 1.

FURTHER EXPERIMENTS CONCERNING IMMUNOLOGIC RECIPROCITY BETWEEN YAWS AND SYPHILIS

By Otto Schöbl

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Additional experimental evidence showing that yaws infection immunizes Philippine monkeys against cutaneous inoculation with syphilis [1] is given in this paper.

Eleven Philippine monkeys that had gone through yaws infection and were proven to be immune to yaws were inoculated with syphilis by intradermal injection on the scrotum. Two normal control animals were included in the test for immunity to syphilis. The shortest interval of time between the first inoculation with yaws and the test for immunity to syphilis was twelve months, the longest twenty-one months. Following the inoculation with syphilis the places of inoculation were inspected regularly for a period of five months. At various intervals of time the inguinal lymph glands corresponding to the point of inoculation with syphilis on the scrotum were removed aseptically and transplanted to the testicles of normal rabbits. The rabbits were inspected weekly for a period of five months and the results were noted. The details are evident from Table 1.

None of the yaws-immune monkeys developed lesions at the places of inoculations with syphilis and none of them harbored viable treponema luis in the lymph glands corresponding to the places of inoculations with syphilis. All normal control monkeys developed typical syphilitic lesions and harbored viable treponema luis in the lymph glands corresponding to the places of inoculation with syphilis.

CONCLUSION

The conclusion drawn from previous experiments [2] that immunity to yaws gained by yaws infection protects Philippine monkeys against cutaneous inoculation with syphilis is hereby confirmed.

[1] Philip. Journ. Sci. 40 (1929) 91. [2] Loc. cit.

TABLE 1.—*Showing the results of inoculation with syphilis performed on monkeys that were successfully inoculated with yaws twelve months or more before and were proven to be immune to yaws.*

[+, typical lesion; ±, immune reaction; —, no lesion; D, died; 0, not done.]

Designation of monkey.	Inoculation with yaws.		Inoculation test for yaws immunity.[a]		Intradermal inoculation with syphilis.		Date of lesion.		Transplants of lymph glands to rabbits.			
	Date.	Result.	Date.	Result.	Date.	Result.	Appeared.	Healed.	Date.	Result.	Lived.	Died.
E–41	[b] II– 1–28	+	II–27–29	—	VI–22–29	—	—	—	IX–11–29	—	One	IX–14–29, one.
W–55	II–29–28	+	II–27–29	—	VI–22–29	D			0			
J–1	VIII–17–28	+	II–27–29	—	VI–22–29	—	—	—	IX–26–29	—	One	XII–9–29, one.
K–9	VI–26–28	+	II–27–29	—	VI–22–29	—	—	—	IX–26–29	—	One	XII–9–29, one.
	VII–19–28	+										
W–51	II–27–28	+	II–27–29	—	VI–22–29	—	—	—	IX–26–29	—	Two	
T–15	IX–17–27	+	II–21–29	—	VI–22–29	—	—	—	X– 2–29	—	Two	
W–8	X–25–27	+	II–21–29	—	VI–22–29	D			0			
W–6	X–21–27	+	II–21–29	—	VI–22–29	—	—	—	X– 7–29	—	Two	
W–43	II– 6–28	+	II–21–29	—	VI–22–29	—	—	—	X– 2–29	—	One	XII–3–29, one.
O–1	VI–21–28	+	II–27–29	—	VI–22–29	±	VII–5–29	VII–10–29	X– 4–29	—	Two	
W–16	XII–12–27	+	II–21–29	—	VI–22–29	—	—	—		—	Two	
SyG–22	0		0		VI–22–29	+	VII–5–29	VIII–17–29	X– 4–29	+	Two	
Control												
SyG–23	0		0		VI–22–29	+	VII–5–29	VIII–17–29	IX–11–29	+	One	IX–29–29, one.
Control												

[a] All normal control monkeys used in the tests for immunity to yaws showed typical yaws lesions containing treponemas.
[b] These letters and figures indicate month, day, and year; thus, II–1–28 means February 1, 1928.

THE XYLOCOPID OR CARPENTER BEES OF THE PHILIPPINE ISLANDS

By T. D. A. Cockerell

Of the University of Colorado, Boulder

In tropical countries even the most unobservant cannot fail to notice the large carpenter bees, nesting in wood, and often to be seen about houses. In the Philippine Islands, as in other parts of the Oriental Region and throughout tropical Africa, two genera may be found. One, *Mesotrichia* Westwood, has the hind part of the thorax flattened, the scutellum having an abrupt rim, while this posterior thoracic truncation faces a similar basal truncation of the abdomen. The basal segment of the abdomen in most (but not all) species contains a pouch, which opens on the anterior face, and in this pouch will be found mites of the genus *Paragreenia.* In the other genus, *Xylocopa,* the thorax is rounded as in other bees, and the first abdominal segment also lacks a sharp or angular rim above its basal declivity.

The Philippine Xylocopidæ are fairly numerous, and are on the whole very closely allied to species of the nearest parts of Asia. There is evidently a tendency to develop insular species or races, and it is probable that many more of these will be discovered on the islands which have not yet been explored for bees. In the present paper *Mesotrichia cuernosensis* is recorded from Cebu, being the first bee to be reported from that island. Also at Uling, Cebu, September, 1925, A. Duyag, entomological collector of the Bureau of Science, took *Apis binghami* Cockerell.

There is a curious parallelism between the modifications of the Philippine xylocopids and those of Africa. Thus we may say that *M. trifasciata,* with its gray-haired head, parallels the African *M. senior* (Vachal). The group of *M. philippinensis,* the females with yellow hair on the hind part of the thorax and the base of the abdomen, parallels the African group of *M. caffra* (Linnæus) and *M. diversa* (Klug). The red-haired *M. cuernosensis* may be compared with the African group of *M. flavorufa* (DeGeer) and *M. mixta* (Radoszkowski).

In 1917 a paper on the carpenter bees was published in the Philippine Journal of Science. It is now quite out of date, and it is worth while to present a revision. In another twelve years, perhaps, another revision may be required, if the present one creates enough interest to promote collecting all over the Archipelago. These bees are so distinctive, and so easily collected, and it may now be hoped so easily identified, that any amateur can add to our knowledge, if situated in a favorable locality. The natural history of the commonest forms still invites study. Their nesting habits, parasites, and natural enemies remain largely unknown, and in many cases we do not know more than one sex, or are not certain about the association of those we know.

Miss Norma LeVeque, of the University of Colorado, is preparing a revision of the *Paragreenia* mites, found in the abdominal pouches of *Mesotrichia*.

Genus XYLOCOPA Latreille

Subgenus NYCTOMELITTA Cockerell

a^1. Large nocturnal bees, with very large ocelli; thorax above covered with dull red or brownish red hair; apical part of abdomen covered with red hair ..... *X. tranquebarica* (Fabricius).

Xylocopa tranquebarica is an Indian species, said to occur in the Philippines but its occurrence there needs confirmation. A closely allied species, *X. grandiceps* (Cameron), occurs from Singapore to Siam; it has much less red hair on the apical part of the abdomen.

Subgenus XYLOCOPA Latreille

a^2. Diurnal bees, the ocelli not specially enlarged.

b^1. Smaller bees, the anterior wing about 16 or, sometimes, as much as 18 millimeters long; face of male narrow, the area below antennæ about as broad as long; sexes differently colored, the male with a good deal of olive-brown hair; the female black with the abdomen dark green..... *X. fuliginata* Pérez.

The type of *X. fuliginata* was from Mindanao; in 1927 Francisco Rivera, one of Mr. McGregor's assistants, collected it at Mati and Mount Mayo, Davao, Mindanao. It is common in Luzon, and is known from Basilan. In Samar is a distinct race, *X. fuliginata indecisa* Cockerell and LeVeque, the female with wings very dark with brilliant purple-blue colors; posterior part of mesothorax more sparsely punctured; abdomen distinctly green, but the color obscure and only well seen on comparison with black.

Xylocopa nigrocærulea Smith, described from Celebes, was recorded from Palawan, Mindoro, and Mindanao by Gribodo. It is practically certain that *X. fuliginata* was mistaken for it; but should it be found it will be known by the flagellum of the female antennæ being testaceous beneath except at the base (black or faintly reddish beneath in the female of *X. fuliginata*); the tarsi rufescent apically (black in *X. fuliginata*); and the wings with coppery iridescence (rosy purple in *X. fuliginata*). Smith described only the female of *X. nigrocærulea.*

The Philippine record of *X. sonorina* Smith, a species of the Sunda Islands, is still more doubtful. The female will be known from that of *X. fuliginata* by the red (instead of black) hair of the anterior tarsi. *Xylocopa mazarredoi* Dusmet, from Palawan, is of this alliance. It is based on a female with the anterior wings 16 millimeters long. I have not seen it, but it must be distinct, by the little darkened wings (strongly darkened in the female of *X. fuliginata*), the partly gray hair, and the red hair on the tarsi. These characters are suggestive of the European *X. cantabrita* Lepeletier, but there is probably no real affinity.

b^2. Larger bees, the anterior wing over 20 millimeters long; face of male broad, the area below antennæ much broader than long. There are several different forms, separable thus:

c^1. Wings brilliant rosy purple, with the apical field peacock green; anterior wing of female 28 millimeters long; abdomen black, without green tints..... *X. dissimilis* Lepeletier.

Xylocopa dissimilis, a Chinese species, has been reported from the Philippines, but probably has been confused with *X. fallax.* Pérez reports a supposed variety of *X. dissimilis* from Palawan, the wings (female) with feeble blue-green and violet reflections, a little coppery in the apical region.

c^2. Wings otherwise colored, not so brilliant; anterior wing, 21 to 26 millimeters.

d^1. Abdomen distinctly greenish; male with larger part of clypeus pale; anterior wing of female, 23 millimeters; of male, 26. *X. fallax* Maidl.

Xylocopa fallax was described from two females and a male collected in the Philippines, the island not stated. It was compared with *X. auripennis* Lepeletier, with which it agrees in the male genitalia; *X. fallax* has the abdomen more densely punctured than *auripennis,* which occurs in Borneo and elsewhere.

Its affinities being with a Bornean species, we may suspect that it came from Palawan.

d^2. Abdomen black.

e^1. Male with only a small part of clypeus (band at upper end) light, but supraclypeal area and broad lateral face marks dull pale yellow, and a yellow mark at each side of anterior ocellus; wings very dark, shining green, with some violaceous. Palawan ..... *X. mimetica* Cockerell.

e^2. Male with lower half or only broad lower margin of clypeus black; anterior wing of female, 21 to 24.5 millimeters long, of male, 22 to 23. Luzon..... *X. mcgregori* Cockerell.

Xylocopa mcgregori, common in Luzon, has been regarded as a race of *X. fallax.* It is very much like *X. pictipennis* Smith, from Java, but *pictipennis* has the third antennal joint conspicuously longer, and the punctures on the clypeus larger and not so dense. The wings are dark, the basal part variably green, the apical field rosy purplish. They are similarly colored in *pictipennis.*

e^3. Male with clypeus, except lower margin, semicircular supraclypeal area, lateral face marks, and the usual marks at sides of anterior ocellus, cream-color; separated from *X. mcgregori* by the almost entirely pale clypeus, large patch of light hair on pleura, and darker hair of mesonotum anteriorly; anterior wing, 21 millimeters long. Ten miles east of Olongapo, Luzon..... *X. thompsoni* Cockerell.

The type of *X. thompsoni* is in the museum of the California Academy of Sciences, San Francisco. It was collected by J. C. Thompson in May, 1907.

Genus MESOTRICHIA Westwood

The type of this genus is an African species, not closely related to those of the Orient; but there is no sufficient reason for recognizing three or four genera as proposed by Ashmead.

Subgenus PLATYNOPODA Westwood

Very large bees, anterior wing over 25 millimeters long; thorax dark above; first abdominal segment without light hair; scutellum not hairy. There are two species, separable thus:

Scape of antennæ not distinctly enlarged at end (a species of the Indian region, probably not occurring in the Philippines). *M. tenuiscapa* (Westwood).

Scape enlarged at end..... *M. latipes* (Drury).

Mesotrichia latipes has two races in the Philippines, which differ as follows:

Wings brilliant green, brassy apically, purple at extreme base. Negros and Panay ..... *M. latipes* (Drury).
Wings very dark, splendid deep purple, the basal half with some bluish green tints. Palawan..... *M. latipes basiloptera* Cockerell.

The anterior legs of the male in this species are greatly modified, the basitarsi broad, flattened, shining, cream color, with very long dark brown hair behind. The eyes of the male are very large, and nearly meet at the top of the head.

The large black female of *M. bombiformis*, if confused with *M. latipes*, is easily distinguished by the hairy scutellum. *Mesotrichia latipes* was recently taken at Lake Dako, Negros, by A. Duyag.

Subgenus KOPTORTHOSOMA Gribodo

This group includes the more ordinary species of the genus, the type of *Mesotrichia* being aberrant. The males are so different in appearance from the females that it is difficult to associate the sexes, and until observations are made of the living bees at their nests, there will remain a good deal of uncertainty. The males appear yellowish or greenish from a covering of hair, and are more alike than the females of the same species. Some species (*M. major, M. vachali, M. clavicrus, M. euchlora,* and *M. subvolatilis*) were originally described from males. *Mesotrichia clavicrus* Maidl, said to occur in Luzon and Ceylon, I have never seen. The male is said to be near *M. volatilis* Smith; the hind femora are extremely broad. In the Philippine fauna it should be readily recognizable by the reddish yellow clypeus. The following table separates the males known to me:

Males of the subgenus Koptorthosoma Gribodo.

1. Hair on apical part of abdomen entirely ferruginous red; hair of thorax above dense and yellow, of hind tibiæ yellow, with a red stripe posteriorly, of hind tarsi with light yellowish red; length, about 21 millimeters; anterior wing, 19; the female is unknown. Mindanao. *M. subvolatilis* Cockerell.

   End of abdomen not thus red haired, though the hair may be partly red or reddish yellow; colors in general usually duller or greener.... 2.

2. Very large robust bee, the anterior wing about 23 millimeters long. Luzon ..... *M. major* (Maidl), which is the male of *M. bombiformis* (Smith).

   Smaller; anterior wing, 20 millimeters or less..... 3.

3. Abdomen thinly hairy, appearing black seen from behind; clypeus very thinly hairy, the surface exposed..... *M. cuernosensis* Cockerell.
   Abdomen more hairy, appearing yellowish or greenish..... 4.
4. Hair of thorax as well as abdomen green; rather large and robust species ..... *M. euchlora* (Pérez).

   This has been thought to be the male of *M. philippinensis*, but I now incline to refer it to *M. ghilianii*. Both *euchlora* and *ghilianii* occur in Mindanao.

   Hair of thorax not distinctly green, but ocherous or yellow..... 5.
5. Clypeus with dense hair, concealing surface..... 6.
   Clypeus with thin hair, not concealing surface..... 7.
6. Larger and more robust, 7 millimeters between tegulæ; colors brighter; marginal cell fuliginous..... *M. confusa* (Pérez).

   Mesotrichia confusa is widely distributed in the Orient, but its occurrence in the Philippines must be considered doubtful; *M. vachali* (Pérez), described from Palawan, is said to be very near to *M. confusa;* the yellow hair of thorax is tinted with red; on abdomen the tint is olivaceous, becoming dusky from the admixture of black hairs. Pérez suggests that it is the male of *M. amauroptera*, the latter name having priority of place.

   Smaller and less robust, hardly 6 millimeters between tegulæ; colors duller; marginal cell subhyaline..... *M. bakeriana* Cockerell.
7. Clypeus more hairy; supraclypeal mark very small; longitudinal light bar on clypeus not meeting yellow of lower margin; abdomen strongly greenish. Samar ..... *M. canaria* Cockerell and LeVeque.

   This is the *euchlora*-like form referred to *M. philippinensis samarensis*, but as was suggested as a possibility at the time, it appears to belong to *M. canaria*. It is extremely close to *M. euchlora*, but the hair of the thorax is evidently more yellow. If this is *canaria*, it seems reasonable to refer *euchlora* to the closely allied *M. ghilianii*.

   Clypeus less hairy; supraclypeal mark large; longitudinal pale band on clypeus uniting with yellow of lower margin; abdomen rather dark (the hair not very dense), not greenish.
   M. philippinensis chlorina Cockerell.

   The male of *M. philippinensis samarensis*, referred to as having the hair of thorax anteriorly suffused with reddish, and the lateral portions of the apical yellow band on clypeus claviform, is little different from *chlorina*, and will run to the same place in the table. This is different from the greenish males, now considered to be *M. canaria*.

In December, 1924, males of *M. major* (*bombiformis*) were taken by A. Duyag at Tapolao, Zambales Mountains, Luzon.

Groups of females of the subgenus Koptorthosoma Gribodo.

The females may be readily sorted into groups as follows:

Thorax covered with bright yellow hair above.... Group of *M. confusa*.
Thorax with red hair (and some black) above; abdomen black.
Group of *M. cuernosensis*.

Thorax with yellow hair in front and behind, but middle or disc black. Group of *M. ghilianii.*

Thorax with a yellow or reddish band or patches posteriorly, but not in front ..... Group of *M. philippinensis.*

Thorax above all black; second cubital cell open at lower basal end. Group of *M. dapitanensis.*

Thorax above all black; second cubital cell complete. Group of *M. bombiformis.*

Thorax above black, but differing from all the above by having the abdomen red except at base..... Group of *M. tricolor.*

Group of Mesotrichia confusa.

Mesotrichia confusa (Pérez) has been reported, but I have never seen it from the Philippines.

Group of Mesotrichia cuernosensis.

Mesotrichia cuernosensis Cockerell is a fine large species, easily recognized by the red hair (mixed with black) on the thorax above and the rosy tint of the wings. It was described from Negros, and has more recently been collected on that island by A. Duyag (Lake Dako, 1925). It is common on Panay. In September, 1925, Duyag took it at Naga and Uling, Cebu. This is the first record of a bee from Cebu.

Although *M. cuernosensis* appears to have no close relative in the Philippines there is a very similar species (superficially appearing practically the same), *M. tambelanensis* Cockerell, on Big Tambelan Island, in the southern part of the China Sea.

Group of Mesotrichia ghilianii.

These large and handsome forms are sufficiently diversified to have given occasion for seven specific names, and it is certain that other segregates will be discovered in still unexplored localities. The following key will facilitate recognition:

Key to the females of the Mesotrichia ghilianii group.

1. Head densely gray-haired; otherwise very like *M. nigroplagiata* (Ritsema), from the Aru Islands; first abdominal segment densely yellow-haired; length, 21 to 22 millimeters. Mindanao. *M. trifasciata* (Gribodo).

   Head not thus gray-haired ..... 2.

2. First abdominal segment with conspicuous yellow hair..... 3.

   First abdominal segment appearing black, but the lens may show a little yellow hair ..... 4.

3. Yellow hair of first segment lacking posteriorly; wings beautiful green, practically without purple; yellow hair of thorax more extensive than in *M. ghilianii,* with a conspicuous line above tegulæ, so that the disc

of mesothorax has a very large subquadrate black patch, broader than long, its outline more or less trilobed posteriorly; extreme base of wing with a tuft of yellow hair (a black tuft in *ghilianii*); abdomen much less densely and roughly sculptured than in *ghilianii*, and ocelli much smaller. Samar..... *M. canaria* Cockerell and LeVeque.

Yellow hair covering first segment dorsally..... 4.

4. Larger, length, about 24 millimeters; hair of head practically all black, but a few yellow hairs may be seen on cheeks. Mindanao and Samar. *M. ghilianii* (Gribodo).

Smaller, length, about 21 millimeters; with lemon yellow hair mixed with black on face. Mindanao ..... *M. blüthgeni* (Dusmet).

Mesotrichia canaria is also larger than *blüthgeni*, about 23 millimeters long, with anterior wing 21; wing of *blüthgeni*, 20.

5. Abdomen little hairy, the surface exposed; hair of head above black, but thin inconspicuous yellow hair on cheeks and sides of occiput; differs from *M. canaria* by yellow hair on mesopleura being more reduced, forming a triangular patch on upper part; wings with strong blue-green and purple tints; length, about 20 to 22 millimeters; anterior wing, 20 to 21. Lucban, Tayabas Province, Luzon. *M. lucbanensis* Cockerell.

Abdomen strongly hairy, the hair more or less concealing the surface; species closely allied to *X. nobilis* Smith, from Celebes..... 6.

6. Head with black hair; anterior yellow band broader; wings dark brown, with very feeble greenish and bronze reflections. Mindanao. *M. adusta* (Pérez).

Head with hair whitish behind, yellowish on vertex; anterior band of thorax narrower; clypeus keeled. Mindanao.... *M. occipitalis* (Pérez).

Pérez states that the second cubital cell is smaller in *M. adusta* and *occipitalis* than in *ghilianii*.

In the above tables *M. trifasciata, blüthgeni, adusta,* and *occipitalis* were placed from the descriptions. It will be noticed that they all come from Mindanao, which seems to have an extraordinary concentration of species. Hedicke (1926) recorded *M. blüthgeni* from Puerto Bangco (probably Port Banga), Mindanao, and considered it valid. A specimen collected by F. Rivera at Mati, Davao, Mindanao, March, 1927, is evidently *M. blüthgeni*. It is certainly very much like *M. ghilianii*, but evidently smaller, with an admixture of yellow hair in the region about the antennæ. The wings do not differ in color from those of *M. canaria*, and the little tuft at the base of the anterior wings is yellow as in *M. canaria*, not black as in *M. ghilianii*. The yellow hair on the first segment covers the surface as in *M. ghilianii*. The clypeal keel is quite strong. Thus the species resembles *M. ghilianii* in some respects, and *M. canaria* in others, but is definitely separable from both.

Another female, obtained by Rivera in the same locality, but in April, appears at first sight to be exactly the same as *M.*

blüthgeni. At first I could hardly persuade myself that it was more than a variation, but it is a distinct species, differing thus: Head with gray hair, conspicuous on cheeks, strongly mixed with black on vertex and face; clypeus dull and more closely punctured (in *blüthgeni* with smooth spaces between the very large punctures in the central portion); clypeal keel very slender, hardly shining; hair below clypeal margin red (dark in *blüthgeni*); and admixture of yellow hairs on occiput; abdomen in middle of second segment much less hairy and less closely punctured; wings with the same appearance and color, but second cubital cell short and open at base. The first abdominal segment is covered with yellow hair. This is *M. trifasciata* (Gribodo), to which it runs in the key.

Group of Mesotrichia philippinensis.

1. Very small; length, 15 millimeters; breadth, 6.5; like *M. philippinensis*, but much smaller, with hind margin of thorax with yellow hair band; pleura black-haired. Luzon ..... *M. bilineata* (Friese).

   This was described by Friese in 1914 from one specimen. No other has been found, and I have not seen it. So far as the description shows, the wings do not differ from those of *M. philippinensis.*

   Larger, at least 18 millimeters long..... 2.

2. Wings dark rosy purple, at most with a little greenish apically; posterior yellow band reduced to lateral patches (which is not true of *bilineata*) ..... 3.

   Wings at least largely greenish, or golden green..... 4.

3. Very large; anterior wing, about 24 millimeters long; yellow hair at sides of thorax posteriorly, below base of wings, and on first abdominal segment. Luzon..... *M. philippinensis* (Smith).

   Very small; about 18 millimeters long, anterior wing, 16.7 millimeters long; reddish yellow hair well developed at sides of scutellum, yellow patch beneath base of wings very small. Malinao, Tayabas, Luzon (*Baker 3661*)..... *M. philippinensis tayabanica* var. nov.

   For the present I regard *tayabanica* as a variety of *philippinensis*, but it may prove to be a distinct species. In the British Museum I saw three specimens marked "sent as *philippinensis*," and noted that they were much smaller. Probably they are *tayabanica*, but I cannot now be sure.

4. Hair of thorax posteriorly yellow. The common form in Luzon; recently collected specimens are from Anuling, Zambales, December 19, 1924, *A. Duyag;* and Antipolo, Rizal, January, 1925, *A. Duyag.*

   M. chlorina (Cockerell).

   I have always considered *chlorina* a race of *philippinensis*, but it is probably a distinct species. It is, however, variable as set forth in Philippine Journal of Science 16 (1920) 206.

   Hair of thorax posteriorly reddish; less white hair on face than in *chlorina*, the general effect in lateral view being black, with hardly any white. Samar ..... *M. samarensis* Cockerell and LeVeque.

Described as *M. philippinensis samarensis*, but if *chlorina* is considered a species, it must either rank as a subspecies of that, or as a distinct species.

Dusmet in 1924 described two species from females of the *M. chlorina* group, namely:

Mesotrichia maesoi (Dusmet). Three from Tayabas, one from Dolores, and one without special locality. Length 22 to 23 millimeters; wing 17 to 18 millimeters; specimens in bad condition, but scutellum has lemon yellow hair, and there is a very little on pronotum; wings with golden reflections, and weaker violaceous color basally.

Mesotrichia ceballosi (Dusmet). Two from Manila, and Imugan. Length 20 millimeters; wing 17 millimeters; scutellum with lemon yellow hair; wings with magnificent golden yellow reflections, with a little violaceous.

The type of *M. chlorina* has the anterior wing a little over 17 millimeters; that of *samarensis*, 18.5, though another specimen is larger, with wing 22. The larger *samarensis*, perhaps to be separated, has the reddish hair on the scutellum reduced to small lateral patches. Some time ago I concluded that *maesoi* could not be separated from *chlorina*, and I remain uncertain about *ceballosi*. Dusmet had seven specimens of the *chlorina* group, which he regarded as pertaining to two species, but none at all of the common *chlorina*, so far as appears. Hedicke has recorded *chlorina* from Lamao and Imugan.

Group of Mesotrichia dapitanensis.

Mesotrichia dapitanensis Cockerell, from Dapitan, Mindanao, is a small black species, about 16 millimeters long; anterior wing, 14. The wings are strongly brownish, darker in apical field, reddened in marginal cell, with a greenish golden iridescence, dilute rosy apically. It most resembles *M. bakeriana*, but is much smaller, with the ocelli farther apart, the wings paler and redder, and the process on hind tibiæ different. It was obtained by C. F. Baker.

Group of Mesotrichia bombiformis.

1. With a band of grayish white hair behind eyes; wings very dark, apical part green. Palawan ..... *M. amauroptera* (Pérez).
   With only black hair behind eyes ..... 2.
2. Cheeks, behind eyes, closely punctured; wings with golden-green luster. Luzon ..... *M. bakeriana* Cockerell.
   Cheeks behind eyes shining and very sparsely punctured. *M. bombiformis* (Smith).

The large robust *M. bombiformis,* with anterior wings fully 25 millimeters long, is common in Luzon. Recently collected females are from Anuling, Zambales (*A. Duyag*) ; Irisan, Benguet (*A. Duyag*) ; and Antipolo, Rizal (*M. Ramos*). The scutellum is hairy, at least at the sides. The other species are much smaller.

Group of Mesotrichia tricolor.

Mesotrichia tricolor (Ritsema), a large species, 27 millimeters long, is described from the Sula Islands, and probably does not occur in the Philippine Islands.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM THE PHILIPPINES (DIPTERA), VII[1]

By Charles P. Alexander

Of Amherst, Massachusetts

TWO PLATES

As before, the present report is based entirely on important collections of crane flies received from Mr. Richard C. McGregor. The most important series include material taken in Cagayan Province, northeastern Luzon, in April and May, 1929, by Mr. F. Rivera and further collections made at and above Ube, Laguna Province, at the foot of Mount Banahao, by Messrs. McGregor, Duyag, and Rivera. Under the capable and intelligent methods of collecting employed, our knowledge of the tipulid fauna of Luzon is developing very rapidly. My thanks are extended to the collectors for the privilege of retaining the types in my collection.

TIPULINÆ

TIPULODINA TABUANENSIS sp. nov. Plate 1, fig. 1.

Mesonotal præscutum obscure yellow with four brown stripes that are narrowly margined with brownish black; antennæ bicolorous; basitarsi black, the central third white; wings whitish subhyaline, with a restricted dark pattern; no dark area in cell M.

Female.—Length, about 22 millimeters; wing, 15.

Frontal prolongation of head yellow, with a brown lateral stripe; palpi light brown, the distal end of the terminal segment extensively orange. Antennæ bicolorous; basal segment yellow, tipped with brown; second segment brown; flagellar segments darkened at bases, paling to dirty white at tips; outermost segments more uniformly darkened. Frons light yellow, the vertex reddish brown, the median and lateral portions of the darkened areas more blackish; genæ and ventral surface yellow.

[1] Contribution from the Department of Entomology, Massachusetts Agricultural College.

Pronotum yellow, dark brown medially. Mesonotal præscutum obscure yellow, with four brown stripes that are narrowly margined with brownish black, the intermediate pair separated only by this darkened margin; scutal lobes obscure yellow, each with two brown areas; scutellum obscure yellow, with a brown median line; postnotum gray, the posterior margin with two brown areas. Pleura light yellow, sparsely variegated with black, including a small area immediately above the fore coxa; a small spot dorsad of the midcoxa and a large arcuate area on the pleurotergite. Halteres black, the base of the stem and the extreme base of knobs pale. Legs with the coxæ yellow, the posterior margin of the hind coxæ darkened; trochanters yellow, infuscated apically; femora obscure yellow, the tips of the fore femora very broadly blackened, with a conspicuous white subterminal ring; middle and hind femora more narrowly blackened at tips; fore and middle tibiæ black, with a narrow white ring beyond midlength; posterior tibiæ black with a similar white ring and an additional subbasal slightly narrower white ring; basitarsi black, the central third snowy white; second tarsal segment white, the base narrowly blackened; segments three and four white; terminal segment infuscated. Wings (Plate 1, fig. 1) whitish subhyaline, with a restricted brown pattern; stigma brown, connected with a narrow seam on anterior cord; a narrow dark cloud on m-cu at junction with Cu; wing apex narrowly darkened, most extensive in the radial field, in cell R_3 this darkening inclosing a gray triangle; no darkening in cell M. Venation: R_{1+2} short, less than R_{2+3}, R_3 very long; m-cu about two-thirds as long as the distal section of Cu_1.

Abdominal tergites one and two yellowish brown, the latter passing into brown at margin; succeeding tergites dark brown, segments three to six narrowly margined with yellow; outer segments more uniformly infuscated; sternites more uniformly pale.

LUZON, Cagayan Province, Mount Tabuan, May, 1929 (*F. Rivera*); holotype, female.

This species and the others of this genus now known from the Philippines may be separated by means of the following key:

1. Wings hyaline, iridescent; no dark mark at near midlength of cell M adjoining vein Cu_1 ..... 2.
   Wings tinted with yellow; a dark spot in cell M at near midlength of vein Cu_1 ..... 3.
2. Legs with the basitarsi entirely black..... *T. luzonica* Alexander.
   Legs with the basitarsi black, the central third snowy white.
   T. tabuanensis sp. nov.

3. Dark spot in cell M very extensive, extending across both cells R and M; basitarsi black, with a white ring at near midlength.
T. cagayanensis sp. nov.

Dark spot in cell M reduced, confined to the cell; white leg pattern very much reduced, the tarsi entirely black or with a nearly obsolete pale ring only ..... *T. succinipennis* sp. nov.

TIPULODINA SUCCINIPENNIS sp. nov. Plate 1, fig. 2.

General coloration yellow, the præscutum with four brown stripes; pleura unmarked; legs black, the usual white rings nearly lacking, especially in the male; wings amber yellow, with a dark pattern that includes a small area at near midlength of cell M; male hypopygium small, the appendages inconspicuous; eighth sternite unarmed.

Male.—Length, about 20 millimeters; wing, 18.

Female.—Length, about 26 millimeters; wing, 20.

Frontal prolongation of head ocherous, narrowly darkened on sides; nasus elongate; palpi obscure yellow, the third and basal portion of the fourth segment darkened. Antennæ (male) of moderate length, if bent backward extending about to the root of the haltere; scape obscure yellow; first flagellar segment light brown; remainder of flagellum black, the extreme bases of the proximal segments darkened; flagellar segments elongate, subcylindrical, the basal enlargement small, the verticils shorter than the segments. Anterior part of head ocherous, the posterior portion more infuscated, with a conspicuous dark brown median stripe on the posterior vertex, extending cephalad to the small vertical tubercle.

Pronotum yellow, narrowly dark brown medially. Mesonotal præscutum yellow, with four conspicuous brown stripes that are narrowly bordered by darker; a circular dusky area on lateral margin of præscutum behind the pseudosutural foveæ; scutum golden yellow, the lobes almost covered by extensive brown areas; scutellum yellow, darker behind, with a median brown line; postnotal mediotergite olive brown with a capillary dark median line. Pleura yellow. Halteres dark brown, the base of the stem restrictedly brightened. Legs with the coxæ and trochanters yellow; femora brownish yellow, brighter at base, the tips narrowly blackened, on the fore and middle femora (male) preceded by a vague brighter yellow subterminal ring that is subequal to the darkened apex; tibiæ and tarsi black, in male with indications of a vague pale subbasal ring on tibia; in the female there are very narrow and only vaguely evident obscure whitish rings, one on the fore and middle tibiæ, two on the posterior

tibiæ, and one on the basitarsus beyond midlength. Wings (Plate 1, fig. 2) tinted with light amber yellow, with a dark pattern as follows: Cell Sc; a continuous crossband at cord, extending from the stigma completely across the wing; m and veins M_1 and M_2; outer ends of cells R_2 and R_3 solidly darkened or with a pale center in cell R_3; a small dark cloud in cell M at near midlength, this a little more extensive in the female. Venation: Forks of medial cells shallow; cell 2d A of moderate width.

Abdominal tergites obscure yellow, patterned with brownish black, this including subcaudal and sublateral lines on the segments, with an interrupted dorsomedian line, especially evident in the female; basal ring of tergites brighter, more ocherous, especially in female; lateral margins of tergites pale; subterminal segments blackened; sternites yellowish; hypopygium yellow. Male hypopygium small and inconspicuous. Ninth tergite with the caudal margin subtransverse to feebly concave, the low lateral lobes blackened and setiferous, the median area glabrous. Spinous hooks of the basistyle small, blackened. Eighth sternite unarmed.

LUZON, Laguna Province, Majayjay, Mount Banahao (*R. C. McGregor*); holotype, male, May 10, 1929; allotype, female, May 11, 1929.

Tipulodina succinipennis is very distinct from *T. tinctipes* (Edwards) in the coloration and in the structure of the male hypopygium. *Tipulodina joana* (Alexander) of Japan likewise has the white pattern of the legs greatly reduced, at the same time lacking the dark spot in cell M of the wings.

TIPULODINA CAGAYANENSIS sp. nov. Plate 1, fig. 3.

General coloration dark brown; antennal flagellum black, the incisures narrowly pale; fore and middle femora with a subterminal white ring; fore and middle tibiæ with white subterminal ring; posterior tibiæ with two white rings; all basitarsi black, with a broad white medial ring; wings pale yellow with a heavy brown pattern, including a large area that completely crosses cells R and M at near midlength.

Female.—Length, about 27 millimeters; wing, 18.

Frontal prolongation of head light ocherous, the sides with a narrow dark brown lateral line; nasus conspicuous; palpi with the first segment dark brown, the succeeding two segments brownish yellow, the terminal segment dark on basal half, the

tip paling to yellow. Antennæ with the basal segment black, narrowly pale at base; flagellum black, the incisures very narrowly pale. Center of vertex dark grayish brown, the orbits irregularly ocherous; an oblique velvety-black line immediately behind each antenna, these almost meeting on the midline.

Mesonotal præscutum with the ocherous ground color restricted to the humeral and lateral portions and somewhat more-darkened interspaces; four dark stripes, the intermediate pair separated by a more velvety-black line; a humeral gray triangle; a dusky spot on lateral margin of præscutum before the suture, extended ventrad across the dorsopleural region; scutal lobes chiefly dark brown; scutellum brownish yellow, with a dusky median line; postnotum similarly brownish yellow, the cephalic and especially the caudal portion bordered by dark brown. Pleura chiefly pale, with a whitish pollen, the ventral sternopleurite and pleurotergite variegated with dark brown. Halteres dark brown, the base of the stem narrowly pale. Legs with the coxæ pale, pollinose, the posterior face of the hind coxæ with a dark spot; trochanters chiefly dark brown; fore and middle femora black, the bases obscure yellow, each with a broad white subterminal ring; tibiæ black, with a broad white subterminal ring, this a little narrower than the apex beyond; basitarsi black, with a broad white medial ring, this a little narrower than the black basal portion; second tarsal segment white, the base narrowly blackened; segments three and four entirely white; segment five black; hind legs without the subterminal white ring on femora; tibiæ with two white rings; tarsi as in other legs. Wings (Plate 1, fig. 3) broad, with a pale yellow tint, the dark pattern heavy; cell Sc black; a heavy dark seaming completely crosses the wing at the cord; other broad seams in distal half of outer radial cells, outer end of cell 1st M_2 and all medial veins, as well as the apical margin of the wing; a very extensive brown cloud completely traverses cells R and M; veins black. Venation: Forks of medial cells shallow; cell 2d A of moderate width.

Abdominal tergites dark brown, the narrow basal ring variegated with obscure yellow laterally, caudal margins of segments narrowly ringed with pale; sternites obscure yellow.

LUZON, Cagayan Province, Mount Tabuan, May, 1929 (*F. Rivera*); holotype, female.

The diagnostic features above indicated readily separate this species from the numerous allied forms. The darkened area in

cells R and M is of unusual extent; in most species it is confined to cell M or is lacking.

DOLICHOPEZA (DOLICHOPEZA) ISOLATA sp. nov. Plate 1, fig. 4.

General coloration brown; halteres and legs chiefly brownish black or black; wings with a faint brown tinge, slightly variegated with darker; R_{1+2} preserved as a long basal spur; medial forks deep; abdominal segments obscure yellow, ringed with brown.

Male.—Length, about 10 millimeters; wing, 10.2; antennæ, about 5.

Frontal prolongation of head dark above, pale beneath; palpi black. Antennæ relatively elongate, totaling about one-half the length of the body; scape and first flagellar segment yellow; remaining segments passing into brown, the basal enlargement darker; verticils shorter than the segments; terminal flagellar segment reduced to a tiny button. Anterior portion of head yellow, the posterior portion extensively darkened.

Pronotum darkened medially. Mesonotal præscutum light brown, without clearly defined stripes centers of scutal lobes conspicuously blackened. Pleura yellow, with a dusky transverse girdle on the anepisternum and sternopleurite; dorsal portion of pleurotergite darkened. Halteres brownish black, the base of the stem yellow. Legs with the coxæ and trochanters yellow, the outer face of the middle coxæ slightly infuscated; femora yellow basally, passing into dark brown; remainder of legs black. Wings (Plate 1, fig. 4) faintly tinged with brown; cells C and Sc darker brown, the former slightly more yellowish; stigma long-oval, dark brown, preceded and followed by small cream-colored obliterative areas; wing apex narrowly darkened; restricted brown seams along the cord and distal section of M, more conspicuous on m-cu. Venation: Rs short, nearly straight, a trifle longer than r-m; basal spur of R_{1+2} preserved; medial forks very deep; m-cu some distance before the fork of M; cell 2d A relatively wide.

Abdominal tergites obscure yellow, the incisures of the tergites darkened, the caudal margins more broadly so than the bases; sternites yellow, the caudal margins narrowly ringed with dusky, the outer segments and hypopygium clear yellow.

LUZON, Cagayan Province, Mount Tabuan, May, 1929 (*F. Rivera*).

The only other species of *Dolichopeza* known to me with a similar venation of the radial field is *D. malagasya* Karsch

(Madagascar). The venation in this latter species has been described and correctly interpreted by Osten Sacken.[2]

NESOPEZA ANNULITARSIS sp. nov. Plate 2, figs. 19–21.

General coloration brown; legs brownish black, the tarsi white with a broad black ring at midlength of the basitarsi; wings dusky, the oval stigma dark brown; male hypopygium with the tergite produced dorsad into a narrow plate that divides into two simple parallel lobes separated by a narrow notch.

Male.—Length, 9 to 10 millimeters; wing, 11.5 to 12.

Frontal prolongation of head yellow; palpi black. Antennæ with the scapal segments obscure yellow, the flagellum black; antennæ relatively short, if bent backward extending to the wing root or slightly beyond; flagellar segments gradually decreasing in length outwardly, segments seven to twelve more nearly equal; terminal segment very small; verticils short, unilaterally arranged. Head brown.

Mesonotum opaque brown, unmarked, in one paratype more reddish brown with narrow darker interspaces. Dorsal pleurites dusky, the ventral sclerites paling to light yellow. Halteres brownish black. Legs with the coxæ and trochanters yellow; femora brownish black, their bases restrictedly pale yellow; tibiæ brownish black, the extreme bases whitened; tarsi white, the basitarsi with a blackened ring in the middle, broadest on forelegs where more than one-half the segment is included, narrowest on the hind legs where the band occupies a little more than one-third the segment; on the middle legs the proximal ends of the basitarsi are more infumed. Wings dusky, the small stigma dark brown, preceded and followed by whitish obliterative areas; veins brownish black to black. Venation: Rs a little shorter than R_{2+3}; forks of medial field deep; cell 2d A very long and narrow.

Abdominal tergites dark brown, narrowly ringed with yellow on basal portions; sternites more extensively yellow, the subterminal segments blackened; hypopygium chiefly obscure yellow. Male hypopygium (Plate 2, fig. 19) with the caudal margin of the tergite (Plate 2, fig. 20) produced dorsad into two slender lobes that are separated by a narrow U-shaped notch, the apex of each lobe weakly and unequally bilobed. Inner dististyle as figured (Plate 2, fig. 21). Ninth sternite, 9*s*, relatively large, appearing as a sheathing structure, the apex deeply emarginate,

[2] Berliner Ent. Zeitschr. 31 (1887) 238.

the lobes provided with long conspicuous pale setæ. Ædeagus, *a*, very long, slender and sinuous, lying in the concavity of the ninth sternite, directed dorsad and caudad, gradually narrowed to an acute point.

LUZON, Cagayan Province, Mount Tabuan, May, 1929 (*F. Rivera*); holotype, male; paratypes, 2 males.

Nesopeza annulitarsis is closest to *N. cinctitarsis* Alexander (Luzon), differing in the structure of the male hypopygium, especially the narrow lobes of the tergite and the longer ædeagus.

NESOPEZA ANGUSTAXILLARIS sp. nov. Plate 1, fig. 5; Plate 2, figs. 22, 23.

Closely allied and similar to *N. cinctitarsis*, differing especially in the small, unmodified male hypopygium.

Male.—Length, 8.5 to 10 millimeters; wing, 9 to 10.

Female.—Length, about 11 to 13 millimeters; wing, 10 to 11.

Frontal prolongation of head testaceous yellow; palpi brown. Antennæ brownish black, the second segment yellow; flagellar segments long-cylindrical, with short inconspicuous verticils; segments gradually decreasing in length outwardly, the terminal segment very small. Head brown, the vertical tubercle and frons light yellow.

Mesonotal præscutum uniform brown; scutal lobes brown, each with two darker-brown areas; scutellum brown, the postnotum darker brown. Pleura pale brown, variegated with darker. Halteres elongate, brownish black. Legs with the coxæ yellowish testaceous; trochanters yellow; femora brown, passing into dark brown outwardly; tibiæ black, the extreme bases whitish; tarsi snowy white, the basitarsi with about the central third to half black, narrowest on the posterior legs; in some specimens the proximal white of the basitarsi is more or less obscured, especially on the middle legs. Wings (Plate 1, fig. 5) with a brownish tinge, the small oval stigma dark brown; a seam along vein Cu; apical margin a little infumed; veins brownish black. Venation: Forks of medial cells deep; cell 2d A very long and narrow.

Abdominal tergites dark brown, the segments more or less variegated with yellow on the basal rings, the color more distinct on the outer segments; sternites more yellow, their bases darkened; seventh segment entirely blackened; hypopygium reddish brown. Male hypopygium (Plate 2, fig. 22) very simple in structure. Ninth tergite (Plate 2, fig. 23) neither extensively developed nor arched as in the allied *cinctitarsis* and *annulitarsis;* caudal margin with a broad chitinized median point

and broader bispinous lateral lobes that are separated from the median lobe by oval incisions; inner arm of lateral lobe a slender spine, the outer arm broader and merging beneath into the chitinized lateral portions of the sclerite. Outer dististyle, *od*, a subcylindrical straight dusky lobe that is provided with long conspicuous setæ. Inner dististyle (Plate 2, fig. 22, *id*) an expanded setiferous blade that is extended into an apical arm, as figured. Eighth sternite, 8*s*, extensive, appearing as a sheathing troughlike structure, the caudal margin unarmed.

LUZON, Cagayan Province, Mount Tabuan, May, 1929 (*F. Rivera*); holotype, male; allotype, female; paratypes, 15 males and females. Additional paratypes, Mount Dos Cuernos, April, 1929 (*F. Rivera*); 1 male, Mount Crista, April, 1929 (*F. Rivera*); 1 male, Mount Irid, Rizal Province, December, 1926 (*Rivera and Duyag*).

Nesopeza angustaxillaris is very similar to *N. cinctitarsis* Alexander and N. *annulitarsis* sp. nov., likewise from Luzon, differing very notably in the small simple male hypopygium.

CYLINDROTOMINÆ

STIBADOCERA PUMILA sp. nov. Plate 1, fig. 6.

Size small (length of body or wing about 5.5 millimeters); general coloration black; antennæ approximately as long as the body; wings with a faint dusky tinge, the prearcular and costal regions more blackish; cell M_2 open by the atrophy of m, this character possibly not normal for the species.

Male.—Length, about 5.5 millimeters; wing, 5.5; antenna, about 5.5.

Rostrum and palpi small, black. Antennæ approximately as long as the body; first scapal segment brown, the second yellow; flagellum black; flagellar segments cylindrical, with long erect verticils that are arranged more or less evidently in three whorls. Head polished black, impunctate; head broad, the anterior vertex about one-half wider than the basal segment of scape.

Pronotum dark, reddish medially. Mesonotal præscutum polished coal-black, the stripes smooth, the interspaces coarsely punctate; scutum with the centers of the lobes smooth, the median region punctate; scutellum metallic blue, punctate; postnotum black, punctate. Pleura black, coarsely punctured, the sternopleurite nearly smooth, without punctures; dorsopleural region conspicuously pale yellowish white. Halteres brownish black, the base of the stem restrictedly pale. Legs with the

coxæ obscure yellow, slightly infuscated basally; trochanters yellow; femora brownish black, the bases paler, the tips darker; tibiæ and tarsi black. Wings (Plate 1, fig. 6) with a faint dusky tinge, the prearcular and costal regions more blackened; veins black. Venation: Sc_1 lacking; Sc_2 ending just beyond midlength of Rs, the free tip a short distance before R_{2+3}; r-m connecting with Rs before fork; R_{2+3} oblique; R_{1+2} entirely atrophied; cell M_2 open by atrophy of m, in one wing of type this crossvein indicated by a weak trace; m-cu oblique, more than its length beyond the fork of M and nearly equal to the distal section of Cu_1.

Abdominal tergites black, the outer segments paling to brown; sternites obscure yellow; hypopygium yellowish brown.

LUZON, Laguna Province, above Majayjay, Mount Banahao, May 10, 1929 (*A. C. Duyag*); holotype, male.

The discovery of a cylindrotomine fly in the Philippines is of great interest. The nearest ally is *S. quadricellula* (Brunetti) of India, which differs especially in the larger size, the coloration of the body, and the venation.

LIMONIINÆ

LIMONIINI

LIMONIA (LIBNOTES) CARBONIPES sp. nov.

General coloration orange, the terminal two segments of the abdomen black; legs and halteres black; wings with a strong brown tinge, bordered with darker, most intense in the prearcular and costal regions.

Male.—Length, about 10 to 11 millimeters; wing, 11.5 to 14.

Rostrum brown; palpi black. Antennal scape black; flagellum broken. Head fiery orange, the anterior vertex narrower than the first scapal segment.

Thorax entirely deep orange, including the coxæ and trochanters. Halteres and legs black, only the extreme bases of the femora obscure yellow. Wings with a strong brown tinge, the prearcular and costal regions more blackish; wing apex and a border along the posterior margin infumed, entering the cells as scattered black dots.

Abdomen orange; segments eight and nine, with the remainder of the hypopygium, deep black.

LUZON, Laguna Province, Ube, Mount Banahao, May 29, 1929 (*R. C. McGregor*); holotype, male; Majayjay, June 8, 1929 (*R. C. McGregor*); paratype, male.

Although it is in general similar to *L.* (*L.*) *termitina* (Osten Sacken), I must regard the present species as distinct. The black coloration of the legs and halteres of *carbonipes* provides the most conspicuous characters for the separation of the two forms.

LIMONIA (LIBNOTES) ACROPHÆA sp. nov. Plate 1, fig. 7.

Thorax fulvous; head black; halteres dark brown; legs brownish yellow, the tips of the femora infuscated; wings dusky, the apex more strongly infumed; Sc_1 subequal to Rs; cell 1st M_2 relatively small, shorter than any of the veins beyond it.

Female.—Length, about 7 millimeters; wing, 7.3.

Rostrum and palpi brownish black. Antennæ black. Head black, the orbits very narrowly margined with paler; anterior vertex reduced to a narrow strip.

Pronotum black. Mesonotum almost uniformly fulvous, the scutellum slightly more yellowish, the postnotum a trifle darker. Pleura fulvous-yellow. Halteres dark brown; Legs with the coxæ and trochanters yellow; femora yellow, the tips broadly infuscated tibiæ brown; tarsi more yellowish brown. Wings (Plate 1, fig. 7) with a faint dusky tinge, the apex, especially in the outer radial cells, more strongly infumed; stigma irregularly triangular, darker brown; cell Sc and a seam along vein Cu_1 in cell M dusky; veins dark brown. Venation: Sc_1 ending about opposite r-m, Sc_2 very far from its tip, Sc_1 subequal to Rs; free tip of Sc_2 and R_2 in transverse alignment; cell 1st M_2 relatively small, shorter than any of the veins beyond it; m-cu from two-thirds to nearly its own length beyond the fork of M; vein 2d A nearly straight, diverging gradually from 1st A.

Abdominal tergites dark brown, the sternites abruptly light yellow. Ovipositor with the tergal valves slender, gently upcurved; sternal valves stouter and nearly straight.

LUZON, Laguna Province, Ube, May 18, 1929 (*A. C. Duyag*); holotype, female.

By Edwards's key to the species of *Libnotes*[3] the present species runs out at couplet 55, differing in the wing coloration, the apex being strongly infumed. The long Sc_1 and small cell 1st M_2 are noteworthy characters.

LIMONIA (LIMONIA) LUTEIVITTATA sp. nov. Plate 1, fig. 8.

General coloration dark brown, the præscutum with three ocherous-yellow stripes; centers of the scutal lobes similarly

[3] Journ. Fed. Malay States Mus. 14 (1928) 74–80.

yellow; pleura with a dark longitudinal stripe; legs brown, the tarsi paler; wings with a strong brown tinge, sparsely patterned with darker brown; free tip of Sc_2 lying basad of R_2 a distance nearly equal to its own length.

Female.—Length, about 5.5 millimeters; wing, 5.5.

Rostrum and palpi black. Antennæ black; basal flagellar segments subglobular, soon passing into oval and finally elongate; verticils unilaterally arranged, chiefly in pairs, exceeding the segments. Head black; anterior vertex relatively wide, nearly twice the diameter of the first scapal segment.

Pronotum brown. Mesonotal præscutum with the ground color dark brown, with three conspicuous ocher-yellow stripes, their surface shiny; median stripe on anterior half very indistinctly divided by a capillary dark vitta; scutal lobes ocherous, their mesal and lateral margins with a narrow dark brown line; scutellum dusky; postnotal mediotergite brown, darker brown laterally. Pleura obscure ocherous, with a conspicuous dark brown longitudinal stripe. Halteres brown, the base of the stem narrowly yellow, the knobs blackened. Legs with the coxæ obscure brownish yellow; trochanters yellow; femora brown, their bases slightly paler; tibiæ brown, the tarsi paling to obscure yellowish brown. Wings (Plate 1, fig. 8) with a strong brown suffusion; a sparse darker brown pattern, including seams at origin of Rs, fork of Sc, stigma, cord, and outer end of cell 1st M_2; wing apex conspicuously darkened; veins dark brown. Venation: Sc long, Sc_1 ending about opposite four-fifths the length of Rs, Sc_2 at its tip; Rs strongly arcuated at origin; free tip of Sc_2 lying nearly its own length basad of R_2; cell 1st M_2 a little widened outwardly, exceeding vein M_4 beyond it; m-cu at fork of M, exceeding the distal section of Cu_1.

Abdomen dark brown. Ovipositor with the tergal valves reddish horn color, relatively small and slender.

LUZON, Cagayan Province, Mount Crista, April, 1929 (*F. Rivera*); holotype, female.

Limonia luteivittata is readily told by the combination of diagnostic features listed above. The ocherous-yellow pattern on the dark brown mesonotum is very conspicuous.

LIMONIA (LIMONIA) MULTINODULOSA sp. nov. Plate 1, fig. 9; Plate 2, figs. 24, 25.

General coloration brownish yellow; antennæ (male) nodulose, the basal eleven flagellar segments with elongate glabrous apical necks; tarsi pale, the posterior tarsi and tips of the posterior

tibiæ snowy white; wings with a blackish suffusion; Sc long; male hypopygium with the ventral dististyle small, subglobular, the rostral prolongation long and slender.

Male.—Length, about 4.3 millimeters; wing, 5.

Rostrum and palpi black, the latter conspicuous. Antennæ (Plate 2, fig. 24) with the scapal segments brown, the flagellar segments dark brown; basal eleven flagellar segments enlarged, subtriangular, each with a long, glabrous, apical pedicel that is subequal in length to the enlarged basal portion; terminal segment elongate, about one-third longer than the entire penultimate segment, elongate-fusiform; flagellar segments with conspicuous outspreading setulæ and a single outstanding verticil, the latter unilaterally arranged. Head brown, the posterior vertex shiny black.

Mesonotal præscutum brownish yellow with a conspicuous median dark brown stripe and barely indicated pale brown lateral stripes; humeral region more yellowish; remainder of mesonotum brownish yellow. Pleura yellow. Halteres relatively long and slender, black. Legs with the coxæ and trochanters pale yellow; femora brown; tibiæ brown; fore and middle tarsi paling to dirty white; posterior legs stouter, the tips of the tibiæ and all the tarsi snowy white. Wings (Plate 1, fig. 9) with a strong blackish suffusion, the oval stigma darker brown; veins dark brown. Costal fringe relatively long and conspicuous. Venation: Sc long, Sc_1 extending to just before the fork of Rs, Sc_2 at its tip; basal section of R_{4+5} elongate, approximately two-thirds Rs; cell 1st M_2 closed, shorter than any of the veins beyond it; m-cu close to fork of M.

Abdomen dark brown, the sternites more testaceous-yellow; hypopygium brownish yellow. Male hypopygium (Plate 2, fig. 25) with the tergite, 9*t*, transverse, each lobe with four long setæ near caudal margin, the median region produced into a depressed sheet that is densely set with setulæ. Basistyles, *b*, elongate, the ventromesal lobe at base. Dorsal dististyle, *dd*, a slender, gently curved rod. Ventral dististyle, *vd*, very small, subglobular, the rostral prolongation long and slender, nearly as long as the dorsal dististyle, without evident spines. Gonapophyses, *g*, with the mesal apical lobe long, of nearly equal width for the entire length.

LUZON, Laguna Province, above Ube, Mount Banahao, altitude 500 meters, September 1, 1929 (*R. C. McGregor*); holotype, male.

Limonia multinodulosa is quite distinct from other described regional species of the genus, the most notable features being the structure of the antennæ and male hypopygium.

LIMONIA (GERANOMYIA) PHŒNASPIS sp. nov. Plate 1, fig. 10; Plate 2, fig. 26.

General coloration of thorax reddish; rostrum black; legs brown, the tarsi paling to yellow; wings tinged with brownish, the stigma only slightly darker; Sc long; abdominal tergites dark brown, the sternites paler; male hypopygium with the two rostral spines of the ventral dististyle very elongate, arising from a single fleshy tubercle.

Male.—Length, excluding rostrum, about 4 to 4.2 millimeters; wing, 4 to 4.4; rostrum, about 1.5 to 1.6.

Rostrum of moderate length, black. Antennæ dark brown throughout; flagellar segments oval, the terminal segment a little smaller than the penultimate. Head gray; anterior vertex reduced to a mere line or with the eyes actually contiguous.

Thorax reddish, the pronotum and dorsopleural region slightly more infuscated. Halteres short, infuscated, the base of the stem narrowly paler. Legs with the coxæ and trochanters yellow; femora and tibiæ brown, the tarsi paling to yellow. Wings (Plate 1, fig. 10) tinged with brownish, the suboval stigma only slightly darker; veins brown. Venation: Sc_1 ending just beyond midlength of Rs, Sc_2 not far from its tip, Sc_1 alone a little less than R_2; cell 1st M_2 closed; m-cu some distance before the fork of M, shorter than the distal section of Cu_1.

Abdominal tergites and hypopygium dark brown; sternites obscure brownish yellow. Male hypopygium (Plate 2, fig. 26) with the tergite, 9*t*, transverse, the caudal margin with a very low emargination. Basistyle small. Dorsal dististyle a strongly curved sickle-shaped pale hook. Ventral dististyle, *vd*, very large and fleshy, the rostral prolongation slender, bearing a single very large and conspicuous fleshy tubercle that is larger than the prolongation itself; at apex of tubercle bearing two very long straight spines. Gonapophyses, *g*, with the mesal apical lobe a small acute spine.

LUZON, Cagayan Province, Mount Tabuan, May, 1929 (*F. Rivera*); holotype, male; paratype, male.

Limonia (*Geranomyia*) *phœnaspis* is very distinct from all described members of the subgenus.

HELIUS (HELIUS) ARGYROSTERNA sp. nov. Plate 1, fig. 11; Plate 2, fig. 27.

General coloration black; femora dark brown, the tibiæ and tarsi white; wings tinged with brown, the costa and apex darker;

abdomen black, the sternites with silvery areas before caudal margin.

Male.—Length, about 5 to 5.5 millimeters; wing, 4.5 to 5.

Female.—Length, about 5 to 6 millimeters; wing, 4 to 5.3.

Rostrum black, of moderate length, a little exceeding the remainder of head; palpi black. Antennæ brownish black throughout; flagellar segments long-oval to subcylindrical, the verticils long and conspicuous. Head black.

Thorax black, the pteropleurite a little paler. Halteres black, the extreme base of the stem pale. Legs with the coxæ and trochanters brownish black; femora dark brown, paler basally; tibiæ and tarsi white. Wings (Plate 1, fig. 11) tinged with brown, the stigma, cells C and Sc, and wing apex more blackened; a vague longitudinal seam along vein Cu, with less distinct seams along most of the other longitudinal veins; veins dark brown. Venation: Sc_1 ending beyond the fork of Rs, Sc_2 at its tip; branches of Rs long but strongly divergent; cell 1st M_2 relatively small, all veins beyond it relatively elongate; m-cu at or close to fork of M; cell 2d A relatively narrow.

Abdominal tergites black, the bases of the segments a trifle paler; hypopygium black; sternites brown, the incisures blackened; a conspicuous silvery area on sternites two to seven inclusive, just before caudal margin. Male hypopygium (Plate 2, fig. 27) with the outer dististyle, *od*, only gently arcuated, the tip very weakly bifid. Inner dististyle, *id*, longer, the apex strongly curved. Basistyle with the mesal face provided with abundant erect setæ but without other armature. Ædeagus, *a*, elongate. Ovipositor with the base of the tergal valves black; valves very long and slender, nearly straight; sternal valves yellowish, stouter than the tergal valves.

LUZON, Cagayan Province, Mount Tabuan, May, 1929 (*F. Rivera*); holotype, male; Mount Dos Cuernos, April, 1929 (*F. Rivera*); allotype, female. Paratypes, one male with the type; one male with the allotype; one male, Ube, Laguna Province, May 18, 1929 (*A. C. Duyag*).

Helius argyrosterna is very distinct from all regional species.

ORIMARGA PERPICTULA sp. nov. Plate 1, fig. 12; Plate 2, fig. 28.

General coloration ocherous; lateral margins of præscutum and the pleura heavily silvery pruinose; legs yellow, the femoral tips broadly, the tibiæ very narrowly darkened; wings broad, pale yellow, with a heavy brownish gray clouding; Sc and 2d A long.

Male.—Length, about 4.8 millimeters; wing, 3.

Rostrum reddish; palpi darker. Antennæ black, the outer segments of the flagellum paler; flagellar segments nearly globular, decreasing in size and becoming more elongate outwardly. Head chiefly dark brown.

Mesonotum light ocherous, the præscutum with a capillary black median vitta on the anterior half; humeral and lateral regions silvery pruinose; postnotal mediotergite somewhat darker. Pleura chiefly dark brown, the surface heavily pruinose with silvery. Halteres orange-yellow, the central portion of the stem more dusky. Legs with the coxæ reddish, narrowly darkened at bases; trochanters reddish; femora yellow, the tips conspicuously brownish black; tibiæ yellow, the tips narrowly infuscated; tarsi yellow. Wings (Plate 1, fig. 12) unusually broad for a member of this genus; ground color creamy, the surface heavily variegated with brownish gray clouds, placed at arculus, origin of Rs, fork of Sc, along the irregular cord, tip of R_3, m-cu and as conspicuous seams on M, 1st A and in cell 1st A near the angulation of vein 2d A; conspicuous marginal darkenings at ends of the longitudinal veins; veins yellow, blackened in the clouded areas, C brighter yellow. Costal fringe very long and conspicuous, yellow. Macrotrichia of veins unusually sparse, the only ones in the radial field being a close series on the distal half of R_{4+5}. Venation: Sc much longer than in *O. pictula*, Sc_1 extending to shortly beyond m-cu, Sc_2 at its tip; Rs angulated at origin; R_1 extending very close to the incrassated costa, very faint and pale to almost obsolete; R_3 angulated and spurred at outer end; basal section of R_{4+5} strongly arcuated to weakly angulated before midlength; cell M_3 relatively deep, vein M_4 exceeding vein M_{3+4}; vein 2d A unusually long for an *Orimarga*, ending opposite the angulation of Rs; anal field unusually expanded.

Abdomen light orange-brown, the sternites slightly more yellowish, the lateral margins narrowly dusky; hypopygium pale. Male hypopygium (Plate 2, fig. 28) with the outer dististyle, *od*, a long, gently curved, blackened rod, the tip acute. Inner dististyle of approximately equal length, slender, pale, with conspicuous setæ, including a group of four small tubercles before midlength.

LUZON, Laguna Province, Ube, May 20, 1929 (*A. C. Duyag*); holotype, male; Mount Maquiling (*C. F. Baker*), a fragmentary paratype male.

Allied to *Orimarga pictula* Edwards (Key Islands), differing especially in the details of venation, notably the longer Sc and 2d A. The dilation of the anal field somewhat suggests the more-accentuated condition in the allied Ethiopian genus *Protorimarga* Alexander.

HEXATOMINI

EPIPHRAGMA CRENULATA sp. nov. Plate 1, fig. 13; Plate 2, fig. 29.

General coloration of mesonotum ashy gray; remainder of body chiefly yellow; basal segments of antennæ pale yellow, the remainder dark; basal two or three flagellar segments united into a single fusion segment; legs yellow; wings light brown, the costal margin clearer yellow; axillary margin crenulate; a series of supernumerary crossveins in costal cell; a supernumerary crossvein in cell Cu; m-cu close to the fork of M; male hypopygium with the interbasal process bilobed at apex.

Male.—Length, about 6.5 millimeters; wing, 6.

Female.—Length, about 8 millimeters; wing, 6.5.

Rostrum brownish gray; palpi brown, small, apparently reduced in number of segments. Antennæ with the scapal segments very pale yellow to dirty white; basal fusion segment of flagellum yellowish white; remainder of flagellum brown; antennæ short in both sexes; a distinct fusion segment at origin of flagellum, involving flagellar segments one and two and a partial fusion of segment three, more complete in the male; verticils longer than the segments, lacking on the scapal and fusion segments. Head with the anterior vertex ashy gray, the posterior vertex yellowish brown with a darker central area.

Mesonotal præscutum flattened, the dorsal portion abruptly light ashy gray, the humeral and lateral portions orange-yellow, the two colors narrowly delimited by a brownish line; transverse suture yellow, the lateral portions poorly defined; scutum light ashy gray; scutellum more brownish gray; postnotal mediotergite dark, slightly pruinose, the lateral portions obscure yellow. Pleura and pleurotergite light yellow. Halteres relatively elongate, pale yellow, the knobs weakly infuscated. Legs with the coxæ and trochanters pale yellow; femora yellow, the tips slightly paler yellow; tibiæ and tarsi pale yellow, only the outer segments of the latter darkened. Wings (Plate 1, fig. 13) with a light brown tinge, the prearcular and costal regions light yellow, the latter continued around the margin to beyond the wing tip, but interrupted by conspicuous brown spots at ends

of the longitudinal veins; very narrow dusky seams on all crossveins and deflections of veins, in addition to a series of reduced marginal dots on the medial veins and all veins caudad of these; veins brown, more yellowish in the flavous areas. Axillary region of wing conspicuously incised, producing a rounded basal lobe. Venation: A series of from five to nine supernumerary crossveins in cell C; m-cu close to the fork of M; a supernumerary crossvein in cell Cu, immediately basad of the level of origin of Rs.

Abdomen pale brownish yellow, the sternites brighter yellow; hypopygium obscure yellow. Male hypopygium (Plate 2, fig. 29) with the outer dististyle, *od*, terminating in a curved chitinized point. Interbasal process, *i*, of moderate length, bilobed at apex.

LUZON, Cagayan Province, Mount Tabuan, May, 1929 (*F. Rivera*); holotype, male; allotype, female.

Epiphragma crenulata is a strikingly distinct species. At first sight, the characters of a fusion segment involving the basal segments of the antennal flagellum, the incised axillary region of the wing, and the presence of a supernumerary crossvein in cell Cu would appear to warrant the erection of a new generic or subgeneric group. However, most of these characters are presaged or indicated in other Philippine species of the genus, especially the antennal fusion and presence of a supernumerary crossvein in cell Cu. The various subspecies of *Epiphragma bakeri* Alexander, as defined in the preceding part under this general title,[4] will probably be found to warrant full specific rank. This is certainly the case with *Epiphragma ochrinota* Alexander, a male of which was taken at Ube, altitude 500 meters, August 30, 1929, by Rivera, and which has the interbasal process of entirely different form from the other species, being elongate and gradually narrowed into an acute sinuous spine. This species, among others, shows an evanescent supernumerary crossvein in cell Cu.

PSEUDOLIMNOPHILA LUTEITARSIS sp. nov. Plate 1, fig. 14; Plate 2, fig. 30.

General coloration of mesonotum brown; antennæ black throughout; legs black, all tarsi extensively pale yellow; wings relatively narrow, with a brownish tinge; a supernumerary crossvein in cell Sc immediately basad of origin of Rs; m-cu from one-third to one-half its length beyond the fork of M.

[4] Philip. Journ. Sci. 41 (1930) 303.

Male.—Length, about 5.5 millimeters; wing, 5.2.

Rostrum black; palpi reduced, black. Antennæ black throughout; flagellar segments long-cylindrical, passing into setaceous, the verticils relatively short and inconspicuous. Head blackened.

Mesonotal præscutum light yellowish brown, the humeral region clearer yellow; posterior sclerites of mesonotum somewhat darker brown. Pleura obscure yellow. Halteres dark brown, the base of the stem restrictedly paler. Legs with the coxæ and trochanters yellow; femora and tibiæ brown; tarsi brown, the tips of the basitarsi and segments two and three pale yellow; two terminal tarsal segments darkened; legs long and slender, the tarsi exceeding the tibiæ. Wings (Plate 1, fig. 14) relatively narrow, tinged with brown, cells C and Sc, together with the small narrow stigma, slightly darker brown; veins dark brown. Venation: Sc_1 ending shortly beyond the fork of Rs, Sc_2 a short distance from its tip; a supernumerary crossvein in cell Sc immediately before origin of Rs; R_{2+3+} arcuated; R_{1+2} approximately three times R_2 alone; inner end of cell R_3 pointed; cell M_1 present, longer than its petiole; m-cu from one-third to one-half its length beyond the fork of M; anterior arculus preserved.

Abdomen light brown, the sternites more yellowish; a darker subterminal ring; hypopygium chiefly obscure yellow. Male hypopygium (Plate 2, fig. 30) with the outer dististyle, *od*, unusually long and slender, the tip extended into a gently curved spine, the surface of the style roughened. Inner dististyle nearly as long, cylindrical, the extreme tip suddenly narrowed. Phallosome produced into a two-horned pale plate on either side.

LUZON, Rizal Province, Santa Ines, December, 1926 (*Rivera and Duyag*); holotype, male.

Pseudolimnophila luteitarsis is very distinct from other regional species of the genus. It is possible that the character and position of a supernumerary crossvein in cell Sc is not constant, since it is not known in any other species of *Pseudolimnophila.*

ERIOPTERINI

GONOMYIA (LIPOPHLEPS) BICOLORATA sp. nov. Plate 1, fig. 15; Plate 2, fig. 31.

Head yellow; mesonotum dark brown; thoracic pleura striped; legs dark brown; wings with a strong blackish suffusion, the costal margin abruptly pale yellow; Sc short, Sc_1 ending before

Rs a distance greater than the length of that vein; male hypopygium with the inner dististyle produced into a long needlelike spine.

Male.—Length, about 2.5 millimeters; wing, 3.1.

Rostrum and palpi black. Antennæ with the scapal segments sulphur yellow, more dusky beneath; flagellum broken. Head light yellow, the center of the vertex with a dusky spot.

Anterior lateral pretergites pale yellow. Mesonotal præscutum and scutum dark brown, the extreme lateral margins of the former pale yellow; scutellum obscure brownish yellow, darker medially at base; postnotal mediotergite dark brown, with a yellow area on either side. Pleura dark brown, with a conspicuous longitudinal China white stripe extending from the fore coxæ to beneath the haltere; dorsal pleurites more yellowish brown. Halteres chiefly dusky, the lower surface of the stem light sulphur yellow. Legs with the fore coxæ China white, as above described, the remaining coxæ chiefly darkened, paler apically; trochanters brown; remainder of legs dark brown. Wings (Plate 1, fig. 15) with a strong blackish suffusion, the costal region abruptly light yellow; stigma darker brown than the ground color, preceded and followed by more whitish areas, the former crossing cell R_2 into cell R; other vague pale areas beyond the cord and in the anal field; veins brown, paler in the costal area. Venation: Sc short, Sc_1 ending far before Rs, the distance a little greater than the length of the latter vein; m-cu a short distance before the fork of M.

Abdominal tergites dark brown, the posterolateral portions of the segments vaguely and narrowly obscure yellow; sternites brighter in color. Male hypopygium (Plate 2, fig. 31) with the outer dististyle, *od*, consisting of two connate arms, the outer a long gently arcuated rod, the distal half blackened, at about the basal fourth bearing a slender blackened rod that is weakly notched at apex; inner arm closely applied or fused for approximately one-half the length of the outer style, the free portion bent at about a right angle or more, at apex dilated into a rounded head, the surface of the stem and knob clothed with abundant yellow setæ. Inner dististyle, *id*, an elongate-oval setiferous lobe, the apex produced into a very long pale spine, the acute tip narrowly blackened. Ædeagus, *a*, very slender, curved, subtended on either side by the spatulate gonapophyses.

LUZON, Laguna Province, Ube, Mount Banahao, May 19, 1929 (*A. C. Duyag*); holotype, male.

Gonomyia bicolorata is very distinct from all regional species. It is most similar to *G.* (*L.*) *hackeri* Edwards (Pahang), differing in the darker color of the wings and especially the very distinct male hypopygium.

Genus TRENTEPOHLIA Bigot

The number of known Philippine species of *Trentepohlia* has more than doubled since the publication of the last key to the species.[5] The species now known to inhabit the Islands may be separated by means of the following key:

1. Cell 1st M_2 closed ..... 2.
   Cell 1st M_2 open by the atrophy of m and the two distal sections of M_3. (Subgenus *Trentepohlia* Bigot.) ..... 11.
2. Two branches of M reach the margin; veins Cu_1 and 1st A widely separated at margin. (Subgenus *Paramongoma* Brunetti.) *T. banahaoensis* Alexander.
   Three branches of M reach the margin; veins Cu_1 and 1st A fused for a distance back from the margin (in all Philippine species). (Subgenus *Mongoma* Westwood.) ..... 3.
3. Tips of femora abruptly and conspicuously whitened ..... 4.
   Femora black or pale, with the tips blackened ..... 6.
4. Crossvein m-cu at or beyond midlength of cell 1st M_2; tibiæ with a dark subbasal ring ..... *T. duyagi* sp. nov.
   Crossvein m-cu at or before the fork of M; tibiæ obscure whitish, without distinct darkening ..... 5.
5. R_2 subequal to R_{3+4}; R_2 strongly arcuated, cell R_3 widened at base. *T. saxatilis* Alexander.
   R_2 close to fork of R_{3+4}, the latter thus much reduced; R_2 not conspicuously widened at base ..... *T. tenera* (Osten Sacken).
6. Femora beyond base uniformly darkened ..... 7.
   Femora pale, in cases with the tips narrowly brown or black ..... 9.
7. All tibiæ white at tips, the mid-tibiæ with distal ends feathered. *T. pennipes* (Osten Sacken).
   Tibiæ without whitened tips; no tibiæ with apical feathering ..... 8.
8. Vein R_3 strongly arcuated; cell R_5 longer than M_3, the fusion between veins R_5 and M_{1+2} relatively short, less than the second section of M_{1+2} ..... *T. brevifusa* sp. nov.
   Vein R_3 nearly straight; fusion between veins R_5 and M_{1+2} long, exceeding twice the second section of M_3 ..... *T. riverai* sp. nov.
9. General coloration pale yellow, this including the legs and wings. *T. poliocephala* Alexander.
   General coloration of body and legs not pale yellow ..... 10.
10. Crossvein m-cu beneath cell 1st M_2; all femora and tibiæ narrowly tipped with black ..... *T. ricardi* Alexander.

[5] Philip. Journ. Sci. 33 (1927) 302.

Crossvein m-cu at or close to fork of M; all femora narrowly infumed at tips; fore tibiæ with tips broadly blackened, hind tibiæ with tips more broadly whitened..... *T. luzonensis* Edwards.

11. Tips of femora abruptly whitened ..... *T. bakeri* Alexander.
    Femora either uniformly pale in color or with the tips narrowly blackened ..... 12.
12. Tips of femora and tibiæ conspicuously blackened; wings yellow, unmarked, except for a narrow seam on vein R_5. *T. mcgregori* Alexander.
    Femora uniformly pale in color; wings not patterned as above ..... 13.
13. Wings almost immaculate, only the costal portion broadly suffused with yellow..... *T. holoxantha* Alexander.
    Wings with a conspicuous brown pattern ..... 14.
14. Abdomen reddish, the terminal segments black; wings yellowish subhyaline, the apex dark brown; cord narrowly seamed with brown but not suffusing cell R_1 ..... *T. trentepohlii* (Wiedemann).
    Abdomen entirely black; a dark brown costal area at sector and in cell R_1, in addition to the darkened apex .... *T. pictipennis* (Bezzi).

TRENTEPOHLIA (MONGOMA) DUYAGI sp. nov. Plate 1, fig. 16.

General coloration brown; femora black, the tips narrowly and abruptly light yellow; tibial bases more narrowly pale, followed by a black ring, this broadest on the forelegs, narrowest on the posterior legs; tarsi pale yellow; wings tinged with brown, the costal region more brownish yellow; R_2 at fork of R_{3+4}, cell R_3 large; m-cu beyond midlength of the small cell 1st M_2.

Male.—Length, about 9 millimeters; wing, 8.5.

Rostrum and palpi black. Antennæ with the first segment of scape black, the succeeding segments brown; flagellar segments cylindrical, the verticils very short and inconspicuous. Head black, sparsely pruinose; anterior vertex very narrow.

Mesonotum yellowish brown, the præscutum with the interspaces darker; median region of scutum and the scutellum obscure yellow; postnotum dark brown, vaguely marked with paler. Pleura more yellowish, darker dorsally. Halteres dark brown, the base of the stem narrowly pale. Legs with the coxæ obscure yellow; trochanters yellow; femora brownish black, the tips narrowly and abruptly light yellow; bases of tibiæ similarly but more narrowly white, followed by a black ring of various lengths, on the forelegs including more than one-half the segment, gradually paling to yellow at tips; this dark ring is narrower on the other legs, presumably narrowest on the hind tibiæ (legs detached) where it is distinct only as a narrow subbasal ring; tarsi pale yellow; legs without special armature. Wings (Plate 1, fig. 16) with a strong brown tinge, the prearcular and

costal regions more brownish yellow; stigma elongate, slightly darker brown; wing apex narrowly infumed; vague seams on certain of the longitudinal veins, especially R_4 and Cu_1; axilla and tip of vein 2d A darkened; veins black, paler in the costal region. Venation: R_2 at fork of R_{3+4}, cell R_3 unusually large; cells R_5 and M_3 subequal in length; cell 1st M_2 small, with m-cu beyond midlength; apical fusion of Cu_1 and 1st A slight.

Abdominal tergites light brown, narrowly dark brown laterally; a vague yellow sublateral area on either side before the caudal margin; sternites obscure yellow; hypopygium light brown.

LUZON, Laguna Province, Ube, Mount Banahao, May 18, 1929 (*A. C. Duyag*); holotype, male.

I take great pleasure in naming the species after the collector, Mr. A. C. Duyag, who has added materially to our knowledge of the Philippine crane flies. No very close allies of the fly can be indicated. The position of m-cu beneath cell 1st M_2 is an uncommon feature in the subgenus.

TRENTEPOHLIA (MONGOMA) RIVERAI sp. nov. Plate 1, fig. 17.

General coloration dark brown; legs black, the tarsi paling to yellow; legs relatively short, the tarsi less than the tibiæ; wings tinged with gray, cells C and Sc, together with the wing tip, restrictedly darkened; fusion of Cu_1 and 1st A very slight.

Female.—Length, about 5.5 millimeters; wing, 5.

Rostrum and palpi brown, the labial palpi more yellowish. Antennæ brownish black throughout. Head black.

Mesonotal præscutum uniformly dark brown, the posterior sclerites of the mesonotum more testaceous brown, the postnotum again darkened. Pleura brownish yellow, variegated with brown on the anepisternum. (Halteres broken.) Legs with the coxæ and trochanters yellow; femora and tibiæ black, the tarsi paling to yellow; posterior basitarsi with a long black bristle at base; legs relatively short, the tarsi shorter than either the femora or tibiæ, especially the posterior tarsi. Wings (Plate 1, fig. 17) with a slight gray tinge, cells C and Sc and the wing tip restrictedly darkened; a slight darkening between the anal veins near base; veins brown. Venation: Sc_1 ending a short distance before R_2; R_{2+3+4} about one-half longer than Rs; R_2 approximately equal to R_{3+4}; R_3 oblique, very gently sinuous, cell R_2 widest at margin; cell 1st M_2 small, the inner ends of cells R_5 and M_3 nearly on a level; m-cu at fork of M; apical fusion of Cu_1 and 1st A very slight to merely contiguous.

Abdominal tergites brownish black, the sternites more brownish yellow, darker laterally, the outer segments more uniformly darkened; ovipositor with the valves horn yellow.

LUZON, Cagayan Province, Peñablanca, Bauan, March, 1929 (*F. Rivera*); holotype, female.

The species is dedicated to Mr. Francisco Rivera, to whom we are greatly indebted for many interesting Tipulidæ from the Philippines. *Trentepohlia riverai* is most nearly allied to *T. atayal* Alexander (Formosa), differing in the coloration of the legs and details of venation.

TRENTEPOHLIA (MONGOMA) BREVIFUSA sp. nov. Plate 1, fig. 18.

General coloration dark brown; lateral præscutal stripes usually pale yellow; pleura obscure yellow, dark brown dorsally; legs long and slender, black, the tarsi paling to brownish yellow; wings tinged with brown, the costal region more blackened; vein R_3 arcuated, cell R_2 narrowed at margin; fusion of R_{4+5} and M_{1+2} unusually short.

Male.—Length, about 7 to 8 millimeters; wing, 6 to 7.

Female.—Length, about 8.5 to 9 millimeters; wing, 7.5 to 8.

Rostrum and labial palpi brownish yellow; maxillary palpi black. Antennæ black throughout; flagellar segments long-oval to truncate-fusiform, becoming more elongate outwardly. Head black; anterior vertex very narrow.

Pronotum brown. Mesonotal præscutum yellowish brown, darker medially, narrowly infuscated on lateral margins, the usual lateral stripes in cases pale yellow; remainder of mesonotum yellowish brown to brown, the median region of scutum obscure yellow. Pleura obscure yellow, the dorsal portions dark brown. Halteres brownish black. Legs with the coxæ and trochanters brownish testaceous; femora black, the bases restrictedly pale; tibiæ and tarsi black, the outer segments of the latter paling to brownish yellow; legs long and slender, the tibiæ longer than the femora, the tarsi longer than the tibiæ. Wings (Plate 1, fig. 18) with a brownish tinge, cells C and Sc more blackened; veins dark brown. Venation: Sc_1 ending shortly beyond the oblique R_2; R_{2+3+4} subequal to Rs; R_3 nearly perpendicular at origin, strongly arcuated, cell R_2 narrower at margin than at base; fusion of R_{4+5} and M_{1+2} usually short, varying from less than to subequal to the second section of M_{1+2}; cell R_5 longer than the other cells beyond cell 1st M_2; m-cu at or shortly beyond the fork of M; fusion of Cu_1 and 1st A slight; cell 2d A relatively short and wide.

Basal abdominal tergites obscure yellow, narrowly darkened laterally; succeeding tergites black, hypopygium brownish black; sternites obscure yellow.

LUZON, Cagayan Province, Mount Dos Cuernos, April, 1929 (*F. Rivera*); holotype, male; paratype, male; allotype, female, May, 1929; Mount Crista, April, 1929 (*F. Rivera*), paratype, female; Mount Tabuan, May, 1929 (*F. Rivera*), paratype, male.

The present species would seem to be most nearly allied to *T.* (*M.*) *saxatilis* Alexander.

ILLUSTRATIONS

[Legend: *a*, ædeagus; *b*, basistyle; *d*, dististyle; *dd*, dorsal dististyle; *g*, gonapophysis; *id*, inner dististyle; *od*, outer dististyle; *s*, sternite; *t*, tergite; *vd*, ventral dististyle.]

Plate 1

Fig. 1. *Tipulodina tabuanensis* sp. nov., wing.
2. *Tipulodina succinipennis* sp. nov., wing.
3. *Tipulodina cagayanensis* sp. nov., wing.
4. *Dolichopeza isolata* sp. nov., wing.
5. *Nesopeza angustaxillaris* sp. nov., wing.
6. *Stibadocera pumila* sp. nov., wing.
7. *Limonia* (*Libnotes*) *acrophæa* sp. nov., wing.
8. *Limonia* (*Limonia*) *luteivittata* sp. nov., wing.
9. *Limonia* (*Limonia*) *multinodulosa* sp. nov., wing.
10. *Limonia* (*Geranomyia*) *phœnaspis* sp. nov., wing.
11. *Helius* (*Helius*) *argyrosterna* sp. nov., wing.
12. *Orimarga perpictula* sp. nov., wing.
13. *Epiphragma crenulata* sp. nov., wing.
14. *Pseudolimnophila luteitarsis* sp. nov., wing.
15. *Gonomyia* (*Lipophleps*) *bicolorata* sp. nov., wing.
16. *Trentepohlia* (*Mongoma*) *duyagi* sp. nov., wing.
17. *Trentepohlia* (*Mongoma*) *riverai* sp. nov., wing.
18. *Trentepohlia* (*Mongoma*) *brevifusa* sp. nov., wing.

Plate 2

Fig. 19. *Nesopeza annulitarsis* sp. nov., male hypopygium, lateral.
20. *Nesopeza annulitarsis* sp. nov., male hypopygium, ninth tergite.
21. *Nesopeza annulitarsis* sp. nov., male hypopygium, inner dististyle.
22. *Nesopeza angustaxillaris* sp. nov., male hypopygium, lateral.
23. *Nesopeza angustaxillaris* sp. nov., male hypopygium, ninth tergite.
24. *Limonia* (*Limonia*) *multinodulosa* sp. nov., antenna, male, segments 3 to 5, 12 to 14.
25. *Limonia* (*Limonia*) *multinodulosa* sp. nov., male hypopygium.
26. *Limonia* (*Geranomyia*) *phœnaspis* sp. nov., male hypopygium.
27. *Helius* (*Helius*) *argyrosterna* sp. nov., male hypopygium.
28. *Orimarga perpictula* sp. nov., male hypopygium.
29. *Epiphragma crenulata* sp. nov., male hypopygium.
30. *Pseudolimnophila luteitarsis* sp. nov., male hypopygium.
31. *Gonomyia* (*Lipophleps*) *bicolorata* sp. nov., male hypopygium.

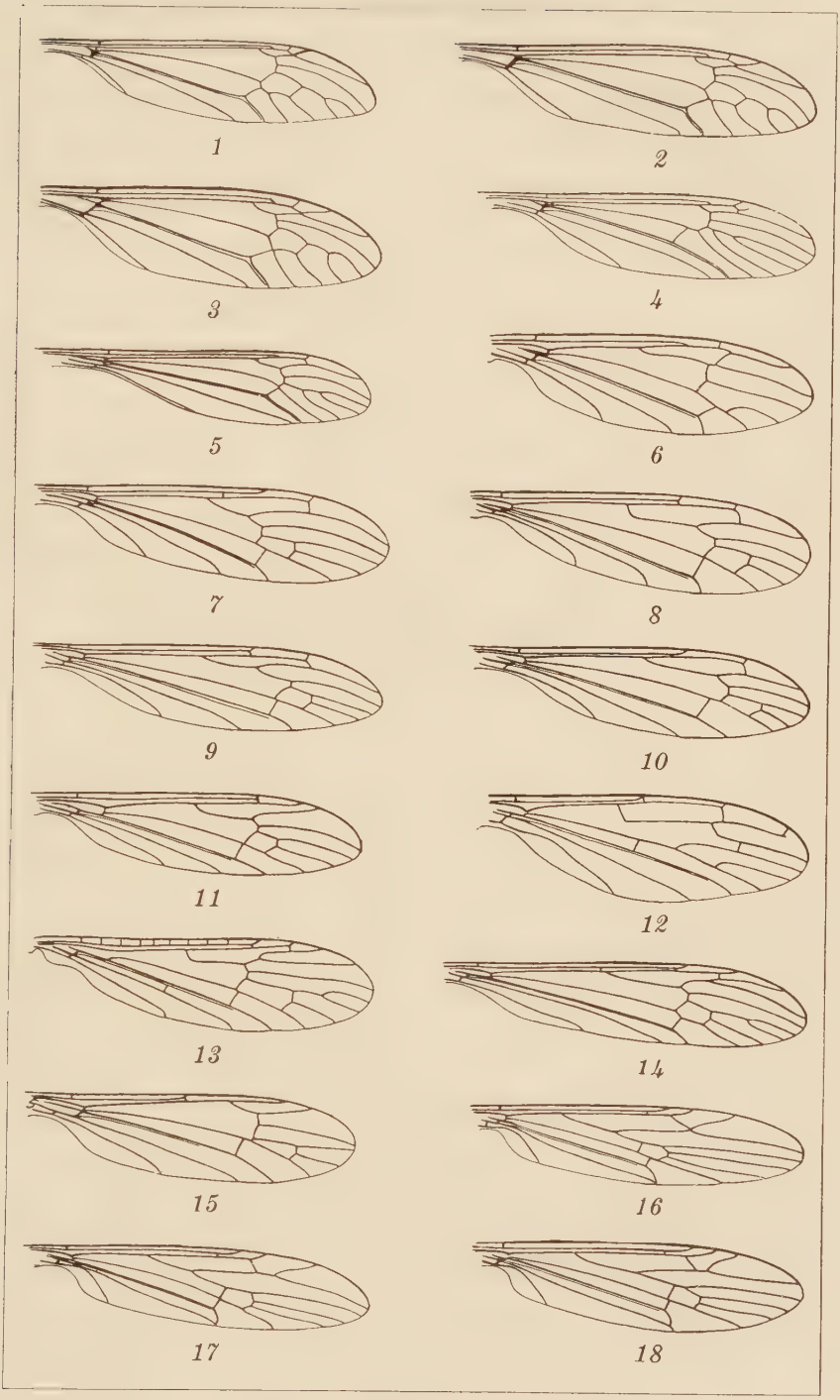

PLATE 1.

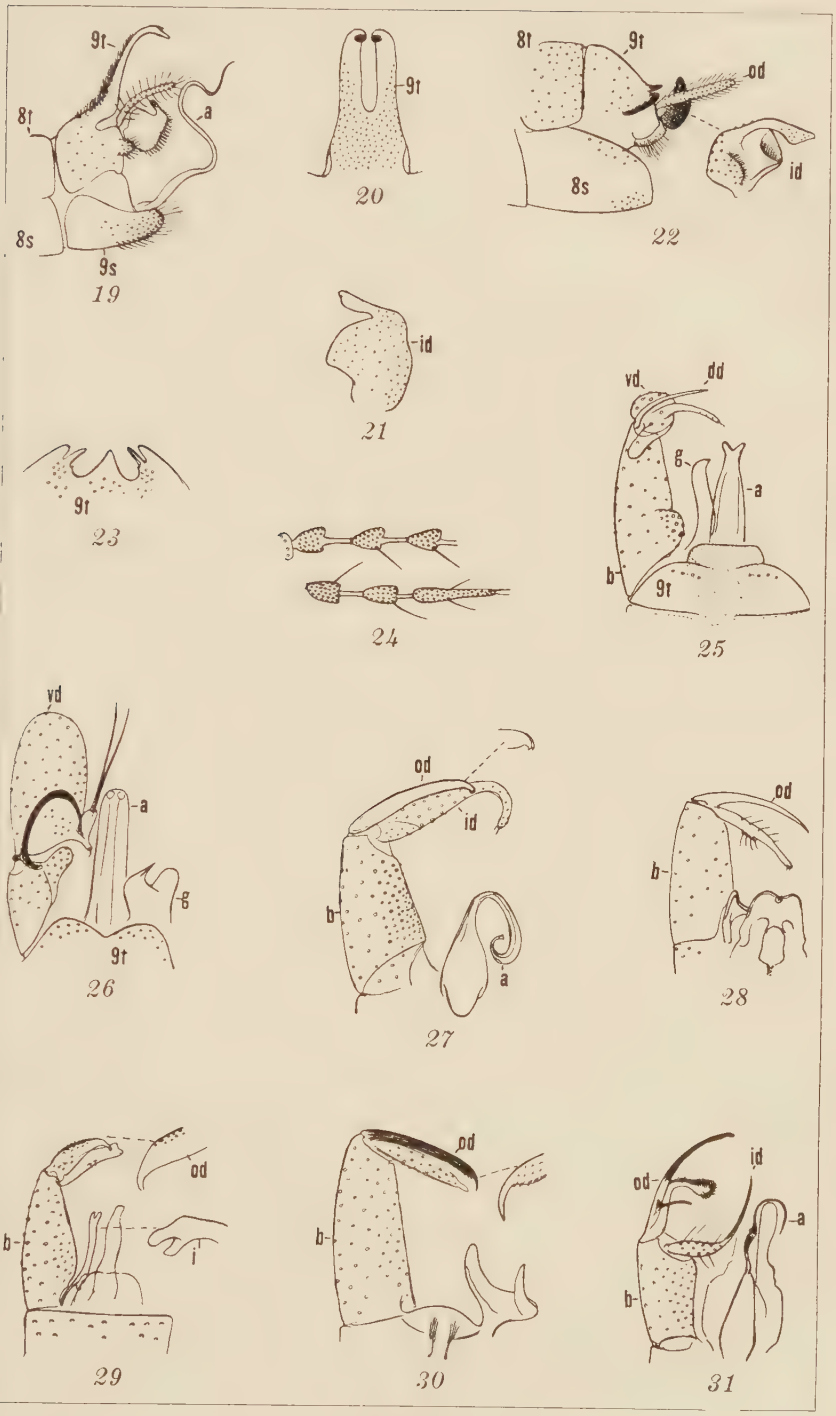
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PLATE 2.

LEAF AND BARK STRUCTURE OF SOME CINNAMON TREES WITH SPECIAL REFERENCE TO THE PHILIPPINE SPECIES

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TWENTY-ONE PLATES AND TWELVE TEXT FIGURES

The members of the genus *Cinnamomum* in general are characterized by the presence of oil and mucilage cells. They constitute a very interesting subject for anatomical study for they are very variable in height; in shape, size, and texture of the leaf; and also in the structure of their flowers. Many of the extreme forms of a given species are so different from one another that often they are considered to be distinct species, while a great number of the recognized species are so intimately connected by intermediate forms that it is very hard to find constant specific characters. In view of this, their external characteristics cannot always be taken as a fixed basis for accurate classification. Since the internal structure is much more constant and less affected by change of environment, any investigation concerning the anatomical structure of the parts, of the members of the genus *Cinnamomum*, will undoubtedly be of great value in throwing more light on the specific distinction of the individual species. This is especially true and important when it applies to the identification of the botanical source of certain parts of the plant, without flowers, used as drugs or medicines.

The number of species of *Cinnamomum* varies; according to Hooker(13) there are about one hundred thirty species of *Cinnamomum* distributed in tropical and subtropical eastern Asia, Australia, and the Pacific. The same number of species distributed more or less in the same regions are indicated by Cooke(5) and by Trimen.(21) Ridley,(19) however, believes that there are one hundred forty species in Indo-Malaya, China, Australia, and Polynesia. Bandulska,(3) on the other hand, in her recent article on a *Cinnamomum* from the Bournemouth

Eocene, claims that there are fifty-four living species of *Cinnamomum* belonging to tropical and eastern Asia and Australia.

In the Philippines Merrill(16) includes only seven species of *Cinnamomum* in his enumeration of Philippine plants and excludes six species. Quisumbing and Merrill(17) described recently two additional endemic Philippine species; namely, *C. microphyllum* and *C. trichophyllum.* The included species in the enumeration are *Cinnamomum mercadoi* Vid., *C. mindanaense* Elm., *C. myrianthum* Merr., *C. sandkuhlii* Merr., *C. zeylanicum* Blm., *C. burmanni* Blm. and *C. iners* Reinw. The first four are endemic, the rest are introduced and are only found in cultivation.

Cinnamomum zeylanicum and *C. cassia* were known universally from time immemorial as the plants yielding the essential oil that has been regarded as the most precious odoriferous substance. Some very interesting historical accounts about their highly priced barks are given by Flückiger and Hambury(9) and Dymock(6) in their respective Pharmacographias. Because of their great economic value, various adulterations and substitutions have been observed. Barks derived from related species, sometimes of inferior quality, are not infrequently sold as cinnamon or cassia lignea, because of their similarity in general appearance and odor. As an instance of this may be quoted the following statement of Flückiger and Hambury(9) with regard to cassia bark.

> Large quantities of a thick sort of cassia have at times been imported from Singapore and Batavia, much of which is produced in Sumatra. In the absence of any very reliable information as to its botanical sources, we may suggest as probable mother plants, *C. cassia* Bl. and *C. burmanni* Bl., var. *chinense,* both stated by Teijsmann and Binnendijk to be cultivated in Java. The latter species, growing also in the Philippines, most probably affords the cassia bark which is shipped from Manila.

The fact that the species *C. burmanni* Blm. var. *chinense,* indicated above, is not common in the Philippines, would suggest that the bark mentioned above by Flückiger and Hambury, shipped from Manila as cassia bark, might have been derived from *C. mindanaense,* a species very similar to *C. burmanni.* Merrill(16) has seen but a single Philippine specimen of *C. burmanni,* from Nagcarlang, Laguna Province, Luzon, and he believes that *C. mindanaense* is the probable species yielding the "cinnamon" exported from Mindanao in the early colonial period. This is quite in accord with the very important historical accounts published recently by Liquette(10) in a local magazine. These accounts are apparently strongly supported by authentic

documents and very reliable references. It is stated that the value of the Philippine cinnamon found growing in Cavite Point, or now known as Caldera Point, Mindanao, had been discovered as early as 1574 in which year about 430 quintals of cinnamon were brought to Manila by the Spaniards. Realizing the prospect and commercial value of the Mindanao cinnamon, they began to promote its cultivation and improve its quality. Various investigations were conducted. A number of samples of barks were sent to Spain for chemical analysis in order to find out how the abundant mucilage, which characterized the cinnamon from Mindanao, could be eliminated. During the administration of Governor Arandia (1754–1759) a large number of Philippine cinnamon trees were planted in Calauan, Laguna Province, Luzon, a place very close to Nagcarlang of the same province. It is quite probable that the plant seen by Doctor Merrill at Nagcarlang might have originated from one of the trees planted at Calauan.

The commonest species of cinnamon trees in the Philippines, long used as spices and as medicine, are *Cinnamomum mercadoi* Vid., which occurs more or less throughout the Islands, and *C. mindanaense* Elm. which is abundant in Mindanao and probably in some other places in the south.

Bacon,(1, 2) working on the chemical constituents of the two Philippine cinnamon plants, observed that the oil from *Cinnamomum mercadoi* consists almost entirely of safrol, which he considers a remarkable thing, as most oils from cinnamon species contain only small amounts of safrol and a large percentage of cinnamic aldehyde; while in *C. mindanaense* he obtained an oil of yellow color and of a strong cinnamic odor and taste with about 60 per cent of cinnamic aldehyde.

As to the internal structure of the parts of the members of this genus there are, so far, only two species where barks have been described by Greenish,(12) Bentley and Trimen,(4) Flückiger and Hambury,(9) Dymock,(6) Reutter,(18) and others. These species are *C. zeylanicum* and *C. cassia.*

Recently Bandulska(3) has published an article describing the cuticular structure of the leaves of *Cinnamomum camphora* Nees and Eberm., *C. zeylanicum* Nees, and *C. burmanni* Blm., in connection with her investigation on a cinnamon from the Bournemouth Eocene.

MATERIAL AND METHODS

The material used in this investigation was obtained from various sources. The barks for the study of *Cinnamomum zey-*

lanicum and *C. cassia* were obtained from Parke Davis and Company, and also from the cultivated Ceylon cinnamon tree in the garden of the University of the Philippines. The bark of *Cinnamomum burmanni* came from the director of Buitenzorg Botanical Garden, Java, while the bark of *Cinnamomum mindanaense* was kindly given to me by Dr. P. Valenzuela, of the School of Pharmacy, University of the Philippines, this being a part of the material he got from Mindanao and from the bark brought by Mr. J. Fontanosa from Misamis, Mindanao. The specimen of *Cinnamomum mercadoi* was collected by Mr. V. Semilla, of the School of Forestry at Los Baños, Laguna Province, from a tree growing at the foot of Mount Maquiling, and the material of *Cinnamomum iners* was taken from the herbarium specimen collected by Dr. C. F. Baker, from Impolutao, Bukidnon, Mindanao.

The sections of the leaves were prepared from the herbarium specimens of the Bureau of Science. Samples from the different specimens of every species were taken and their corresponding sections were compared one with the other.

All the dried materials were placed in water for twenty-four hours before the sections were cut. This was done in order to render the material softer and consequently easier to cut in thinner sections. The fresh material or the material which had been preserved in 5 or 7 per cent formalin solution was cut directly without much difficulty.

The sections of the barks and of the leaves were prepared from 15 μ to 30 μ thick by means of a sliding microtome. Some of the sections were mounted in chloral hydrate solution, others in dilute solution of glycerin, and some were stained with safranin coupled with Delafield's hæmatoxylin and mounted in balsam.

For the study of the secretion cells containing essential oil the following stains were used: (*a*) Tincture of alkanna, which stains the oil content pink or red; (*b*) osmic acid solution, which gradually changes the color of the fixed oils from yellowish to dark brown or nearly black; and (*c*) Soudan red in glycerin, which by warming a section with it, colors the walls of the oil-secretion cells red. The following reagents were used for the special study of the secretion cells containing mucilage: (*a*) Solution of subacetate of lead, which renders the mucilage yellowish in color and makes it granular; or (*b*) a cubic centimeter of 10 per cent solution of lead acetate with a small amount of

ruthenium red, a mixture with a wine-red color, which sometimes stains the mucilage a brilliant pink.

The powder used for the study of *Cinnamomum zeylanicum* was taken from the Lilly's authentic powdered cinnamon bark, and the powder used for *C. mindanaense* was prepared in the laboratory of the School of Pharmacy, University of the Philippines.

Schultze's maceration mixture and methods as described by Greenish(11) were employed in the isolation and study of the individual cells.

CINNAMOMUM ZEYLANICUM BLUME

This moderate-sized evergreen tree is a native of Ceylon and India, grows in Burma and the Malay Peninsula, and is extensively cultivated in other tropical countries. It is one of the most variable species under the cinnamon group, and for this reason it has several synonyms. Meissner,(14) in de Candolle's Prodromus, describes six of its varieties. The tree is variable in height. The bark is reddish brown, rather thick and rough, and has longitudinal and transverse fissures. The young parts are slightly quadrangular, glabrous, with finely silky pubescent buds. The leaves are opposite or subopposite, petiolate, coriaceous, ovate or ovate-lanceolate with obtuse or rounded base, shortly acuminate or obtuse apex, and are strongly 3- to 5-nerved. The young leaves are bright pink or reddish and gradually become green. The panicles are large, terminal, much branched, usually about as long as the leaves, and mostly clustered in the upper axils. The flowers are numerous on rather long, slightly pubescent peduncles, pale yellow, small; the perianth about 7 millimeters long, pubescent outside with grayish hairs, tube short, campanulate, segment oblong-lanceolate, acute or obtuse, persistent. The fruit is about 1 centimeter long, oblong-ovoid, dry or slightly fleshy, dark purple, and surrounded by a much-enlarged perianth.

In the Philippines it is found occasionally cultivated in gardens in large towns, especially in Manila. On Plate 1, fig. 1, a portion of a branch, with flowers, from the tree growing in the garden of the University of the Philippines is represented.

THE LEAVES

General external morphological features.—Full-grown leaves of *Cinnamomum zeylanicum* are usually from 8 to 20 centi-

meters long by 3 to 8 centimeters wide at the widest part (text fig. 1). They are oblong-ovate or sometimes elliptical in outline, petiolate, trinerved, coriaceous, shining, bright green on the upper surface, glaucous beneath, with entire margin. The base is rounded or sometimes obtused, and the apex is bluntly acuminate. The petioles are from 8 to 14 millimeters in length, nearly cylindric and shallowly grooved on the upper part. The two basal lateral veins arising from the petiole may run parallel to the midrib up to 8 millimeters above the base and pass arch-wise towards the apex, but do not reach it. Few secondary veins may or may not be distinct. They usually branch

FIG. 1. *Cinnamomum zeylanicum*, average leaves from different specimens from the Philippines and abroad; *a*, from the garden of the University of the Philippines; *b* and *g*, from Tabogo, West Indies; *c*, from Tondo, Manila; *d*, from Bataan, Luzon; *e*, from Java. × ⅓.

and anastomose with each other, forming a sort of network. This anastomosing is more evident in the lower part of the leaf. When the fresh leaves are crushed between the fingers they give off an aromatic odor, characteristic and peculiar to the cinnamon trees. The taste is sweetish pungent and slightly astringent.

The internal structure of the leaf.—A transverse section of the lamina of a full-grown leaf measures about 0.3 millimeter in thickness and it is bifacial (text fig. 2, *b*). The upper epidermis consists of a single layer of rectangular or sometimes nearly

square and highly cutinized cells with very thick cell walls. Their cavities are greatly reduced and their walls are somewhat striated with depressions simulating simple pits. The lower epidermis is also composed of a single layer of cells of the same shape but thinner and with some stomata and oc-

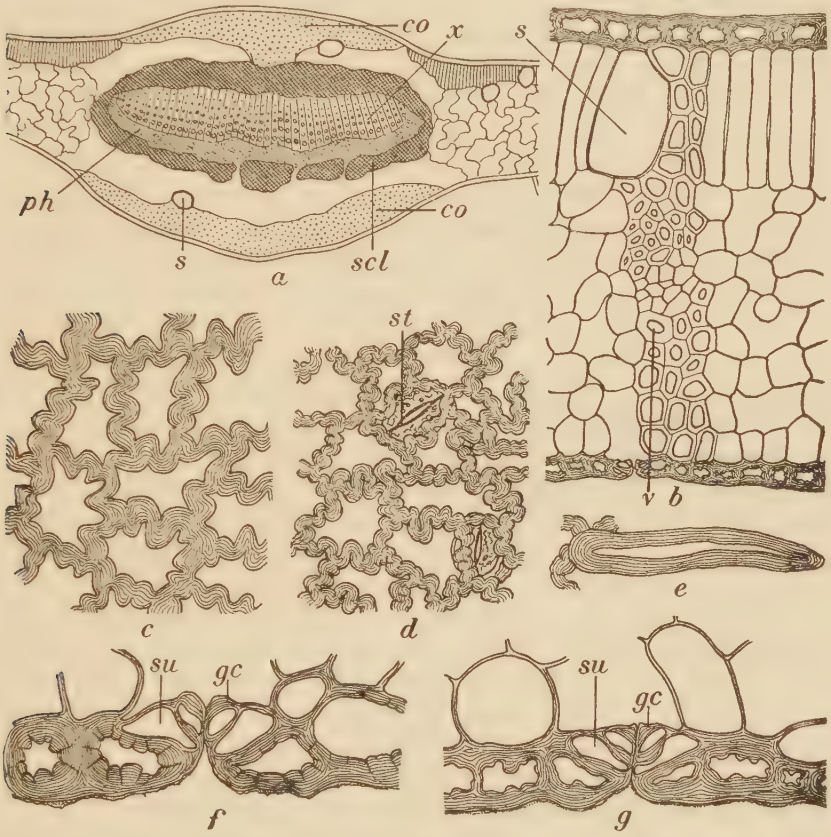

FIG. 2. *Cinnamomum zeylanicum; a*, diagrammatic representation of a transverse section of the midrib (*co*, collenchyma; *scl*, sclerenchyma; *ph*, phloëm; *x*, xylem; *s*, secretion cells); *b*, a segment of a transverse section of the blade (*s*, secretion cells; *v*, vein), × 250; *c*, a portion of the surface view of the upper epidermis, × 540; *d*, a portion of the surface view of the lower epidermis (*st*, stomata), × 540; *e*, a single hair, × 540; *f*, a portion of a transverse section of the lower epidermis showing a stoma from a specimen from Java (*gc*, guard cells; *sc*, subsidiary cells), × 700; *g*, a segment from a transverse section of the lower epidermis of a fresh leaf, × 700.

casionally with one or two unicellular hairs. The stomata appear mostly cut obliquely or sometimes longitudinally and a few transversally. The two small depressed guard cells forming the stoma are bordered and overarched by subsidiary cells which are arranged parallel to the pore and partly covered by inclosing epidermal cells (text fig. 2, *f* and *g*). There is

but one layer of straight-walled, cylindrical, palisade cells which are about 0.075 millimeter long and about 0.01 millimeter wide. Here and there are found large elliptical or rounded structures, between the palisade chlorenchyma or in the upper part of the spongy region, which are known as secretory cells. These secretory cells measure about 0.07 millimeter in length and about 0.045 millimeter in width. They usually contain essential oil and rarely mucilage. In some cases these secretory cells are also found in the lower part of the spongy region. The spongy chlorenchyma consists of irregularly shaped cells measuring usually about 0.035 millimeter in length and 0.012 millimeter in diameter with large intercellular spaces. Very often they have a brownish content. The veinlets are distributed at intervals, sometimes cut obliquely and sometimes transversally. They are vertically transcurrent on both sides by means of more or less differentiated sclerenchymatous cells. These cells have thick and slightly lignified walls with polygonal outline. The xylem region consists of a few small vessels or tracheids bounded in the lower part by a few phloëm cells.

The transverse section cut through the midrib reveals that it is more or less lenticular (text fig. 2, *a*). It is narrowly convex above and broadly convex below. The epidermis of each surface consists of a single layer of nearly rectangular or quadrangular cells with greatly thickened lateral walls and thick cuticles on the outer ones. Below the upper epidermis are collenchyma cells which are grouped in fan-shaped form with the lower, narrower portion extending towards the meristele. The two lateral sides are extended by means of two rows of cells towards the palisade regions. In the inner part of the lower epidermis there are also three or four layers of collenchyma cells stretched out from one side of the midrib to the other.

The parenchyma region just below the meristele is composed of about six or seven layers of thin-walled parenchyma cells with circular outlines and with small intercellular spaces. They contain few starch grains. Very often some secretory cells containing either essential oil or mucilage are found in this region. These secretory cells have the general appearance of the large parenchyma cells with thin walls, but the secretory cells are very much larger and usually contain essential oil or mucilage. The parenchyma in the upper part of the meristele consists of two patches, separated by the lower part of the collenchyma region, each of which is composed of two or three layers of rounded, thin-walled cells with small intercellular

spaces. Occasionally in these regions one or two secretory cells are also found. The meristele is somewhat lenticular in outline. In the outer part it is surrounded by two or three layers of faintly striated, slightly lignified, polygonal, and thick-walled sclerenchyma cells which are arranged in the form of a ring with two or three interruptions in its inner parts. The endodermis is not distinct. The phloëm region is confined to the lower part of the xylem region. The xylem vessels are arranged in radial rows and are from 0.015 to 0.03 millimeter in diameter.

Surface preparation.—The upper epidermis in surface view consists of cells varying from 0.025 to 0.04 millimeter in their greatest diameter and from 0.02 to 0.03 millimeter in their least diameter. They are polygonal in outline with sinuate and very thick cell walls, which measure about 0.007 millimeter and sometimes they are faintly striated (text fig. 2, *c*). The lower epidermis is also composed of more or less polygonal cells with very strongly convoluted cell walls about 0.004 millimeter in thickness. They measure from 0.02 to 0.04 millimeter in the greatest diameter and from 0.015 to 0.02 millimeter in the least (text fig. 2, *d*). Scattered in the lower epidermis there are numerous stomata and few simple unicellular hairs. The stomata are deeply located below the epidermis and partly covered by the neighboring epidermal cells which are five or six in number. They vary in size, and their outline is not quite distinct. The hairs are simple and unicellular with very thick walls (text fig. 2, *e*). They measure from 0.065 to 0.1 millimeter in length.

THE BARK

The fresh bark.—The bark, from the trunk of a tree about 10 years old, when fresh is from 5 to 10 millimeters thick. Externally it is brownish or dark brown, and sometimes greenish brown due to the presence of some pleurococcus. The outer surface is uneven, rough, and irregularly fissured. The outer layer of the cork region is somewhat easily separable. The middle part of the bark is granular on account of the groups of stone cells. The inner surface is creamy white, smooth, and soft. It gradually becomes brownish, especially when exposed to light. The bark is readily fractured by bending, and the fracture surface is uneven and gives an aromatic odor with a sweetish, pungent, and slightly astringent taste.

The fresh barks from branches from 2 to 5 centimeters in diameter or from a stem about 4 years old, are from 1 to 3 mil-

limeters thick. The external part is grayish brown to brownish or sometimes greenish brown like that from the trunk. The outer surface has slight, longitudinal fissures, with rounded or ovoid, dark brown lenticels. The inner surface, like the bark from the trunk, is creamy white, smooth, and soft. The fracture is incomplete, and the odor and taste are also like those of the bark of the trunk.

Commercial cinnamon bark.—Commercial bark is obtained in the form of sticks about 1 meter long, to 16 millimeters wide, and to about 1.2 millimeters thick (Plate 2, figs. 7, *a–d*, and 8). It consists of several overlapping quilled pieces of bark about 30 centimeters long. These quills of bark are deprived of the suberous coat and the greater part of the middle cortical region, and are arranged carefully one within the other, each side being made to curl inward, forming a somewhat cylindrical structure with a groove along one side. One account of this groove, formed by the incurving sides of the bark, in cross section the bark exhibits a reniform outline. The outer surface is light brown, smooth or rough, finely striated with shining slightly undulated lines and occasionally with branch scars or holes. The inner surface of the bark is dark. The fracture is very weak, brittle, and splintery or uneven. The odor and taste are like those of the fresh bark.

Microscopical structure.—A thin transverse section of fresh bark taken from a stem about 4 years old exhibits the following characteristics (Plate 3, fig. 9). The external part consists of a thin periderm which is composed of a single layer of highly cutinized epidermal cells, five to ten layers of thin-walled, slightly suberized, and tangentially flattened cork cells. The cork cells in one of the inner layers have thicker outer walls. The phellogen is not distinct, and the cortex is not sharply defined from the pericyclic region by starch sheath. The cortical part consists of ten to sixteen layers of tangentially elongated parenchyma cells. Some of these cells contain starch grains and others are filled with a brown substance. Intermingled with the inner layers of parenchyma cells a few characteristic cells more or less similar to the parenchyma cells are observed. These are the secretion cells (Plate 3, fig. 14). They differ from the parenchyma cells because they contain essential oil. They are also tangentially elongated and measure from 0.03 to 0.05 millimeter in their greatest diameter and from 0.015 to 0.02 millimeter in their least diameter. When

the secretion cells are treated with alkanna tincture, the contents of these secretion cells become red, while if treated with osmic acid solution their contents become brownish black which evidently proves that they contain essential oil.

The structure of the middle part of the bark, prepared from the fresh material, is the same as that of the section from the dried one of the commercial cinnamon bark (Plate 3, fig. 11). It is built up largely of tangentially elongated, sometimes rounded, thick-walled, pitted, sclerenchymatous stone cells. Their cavities are greatly reduced and sometimes contain starch grains. The inner walls of most of the stone cells are thicker than the outer ones. They measure from 0.05 to 0.12 millimeter in their longest diameter and 0.02 to 0.05 millimeter in their shortest diameter. In the outer part of the stone-cell ring there are one or two layers of tangentially elongated parenchyma cells containing few starch grains and interrupted by groups of small thick-walled cells with polygonal outline (Plate 3, fig. 10). These are the pericyclic fibers which correspond to the primary bast fibers, and they are the tissues that compose the wavy lines observed on the outer surface of the bark as indicated above (Plate 2, fig. 8). In the longitudinal section those sclerenchyma fibers are elongated and tapering at both ends and about 0.25 millimeter long. The inner part of the stone-cell ring is bounded by six to ten layers of parenchymatous, thin-walled, and tangentially elongated cells interrupted by parenchyma-like cells containing essential oils, and by larger cells containing mucilage (Plate 3, figs. 11 and 15). The parenchyma cells towards the phloëm region are smaller and are traversed by medullary ray cells. The medullary rays are mostly two cells wide, and the cells are nearly isodiametric. They have thin walls and in some parts are filled either with small, ovoid or somewhat rounded starch grains, or with minute prismatic or clinorhombic calcium oxalate crystals, or sometimes they are filled with a mixture of both calcium oxalate crystals and starch grains while some of the cells contain a brown substance. The starch grains measure about 0.003 millimeter in diameter, and the crystals of calcium oxalate about 0.0015 millimeter in width and 0.006 millimeter in length (Plate 3, fig. 13).

The remaining part of the section is the bast region, which occupies about one-half of the entire section of the peeled bark. It is composed of phloëm cells, parenchyma, bast fibers, and

secretory cells and is traversed by medullary rays one or two cells wide. Towards the sclerenchymatous ring the phloëm cells often collapse into strands, in which the cell cavities are scarcely visible; but towards the cambial region they appear tangentially elongated. The phloëm parenchyma cells are also, tangentially elongated and they may be rectangular or rounded, contain minute starch grains, and sometimes accompanied by tannic acid or small calcium oxalate crystals in raphides or clinorhombic forms. Scattered throughout the bast region there are conspicuous bast fibers, which are rounded, or four sided, and tangentially elongated, with very thick walls and greatly reduced cavities. They are isolated or in small, often radially arranged groups of three or four. The oil-secretion cells are also found scattered in the bast region, between the phloëm parenchyma cells. They can be easily recognized by their size. When the section is treated with Soudan red in glycerin and gradually warmed to the boiling point and then cooled, the suberized walls of the secretion cells become deep red.

In the radial section the stone cells appear either polygonal or rounded in outline and sometimes radially elongated as illustrated on Plate 3, figs. 12, 16, and 17. The medullary rays may consist of three to six rows of cells. The secretion cells are easily distinguished from the other cells because of their larger size and axially elongated shape. Some of these contain yellowish volatile oil or mucilage, some contain resin, and many are empty. The secretion cells may be observed isolated, or in groups of two, arranged one above the other. The sieve tubes are not distinct, except in a few cases where the transverse walls become prominently exposed. The phloëm parenchyma cells are mostly filled with starch grains and sometimes with few calcium oxalate crystals or with a brown substance. The bast fibers, as in the transverse section, are scattered and isolated or form groups of two or three cells. Their two ends are somewhat pointed.

The powder.—The bark of Ceylon cinnamon, in the powder form, is a light or yellowish brown and has a peculiar aromatic odor, characteristic of its essential oil. The most important elements found under the microscope in the examination of the powder are the bast fibers, the stone cells, secretion cells, the numerous small starch grains, fragments of the other tissues, and often the calcium oxalate crystals (Plate 4, fig. 18, *a–h*). The bast fibers with thick, slightly lignified walls, and spindle shaped are usually found alone or in groups of two, and in the

case of larger fragments they are embedded in a group of other cells. They measure from 0.10 millimeter to 0.800 millimeter in length and from 0.006 to 0.10 millimeter in width. The stone cells are numerous and occur either singly or in clusters of two or more cells. As in the cross-section, they are quite irregular in outline with very thick walls on one side and thinner on the other side. They are colorless, slightly striated, pitted, and contain either a brown amorphous substance or starch grains. The secretion cells are scanty and usually found in fragmentary form. When they are unbroken, they appear like ordinary parenchyma cells except that they are larger and when treated with alkanna tincture their contents become red or brownish red, and if they are treated with Soudan red in glycerin and warmed gradually to the boiling point, their suberized walls become red. The starch grains are numerous and they are either single or compound. The individual grains are spheroidal or polygonal and from 0.003 to 0.020 millimeter in diameter. Fragments of other tissues may consist of the parenchyma cells, sieve tubes, and companion cells or some medullary ray cells. The sieve tubes and companion cells are inconspicuous, and the former can occasionally be distinguished by the character of their transverse walls. The walls of the parenchyma cells are sometimes slightly lignified and pitted. They are usually filled with minute starch grains or brown substance. Sometimes the calcium oxalate in the raphides or clinorhombic forms are observed. They measure from 0.005 to 0.010 millimeter in length.

In the examination of the macerated sections by Schultze's process the most conspicuous elements observed are the secretion cells, the stone cells, and the sclerenchyma fibers. The secretion cells are numerous and they appear either axially elongated, elliptic, or ovoid in shape. They are from 0.025 to 0.09 millimeter long and from 0.012 to 0.03 millimeter wide (Plate 4, fig. 19, *a*). They contain either droplets of yellowish oil, or a brownish resinous substance, or are empty. The starch grains and other tissues are partially destroyed or deformed. Occasionally a fiber consisting of a row of stone cells is found as indicated in Plate 4, fig. 19, *b*, or a cluster of stone cells as shown in the same plate, fig. 19, *c*.

CINNAMOMUM CASSIA BLUME

According to Flückiger and Hambury (9) the various species of *Cinnamomum* occurring in the warm countries of Asia from India eastward, afford what is commonly called cassia lignea or

cassia bark, and the trees are extremely variable in foliage, inflorescence, and aromatic properties. But the true cassia bark has for a mother plant *Cinnamomum cassia* Blume, which is described by Bentley and Trimen(4) as follows:

A handsome tree of moderate size, with the younger branches somewhat tetragono-compressed; bark thick, smooth, pale, young twigs finely tomentose, buds smooth. Leaves evergreen, sub-opposite or alternate, 5–9 inches long, petiole about ½ inch, blade oval-oblong, tapering at base, acute or obtuse at apex, quite entire, very smooth, shining and green above, dull and glaucous with a very minute tomentum beneath, strongly 3-nerved, the nerves impressed above, very prominent beneath, the two lateral ones united with the midrib for a short distance from the base, and reaching the apex of the leaf, transverse connecting veins very numerous. Flowers small, stalked, without bracts, arranged in three and forming small cymose panicles at the end of long axillary and terminal peduncles; peduncles and pedicels finely tomentose or subglabrous. Perianth pubescent on both surfaces, rather smaller than in *C. zeylanicum*, and with the segment more obtuse. Androecium and pistil as in that species. Fruit broadly oblong-oval, apiculate, fleshy, shining, black, surrounded at the base by a cup formed by the persistent base of the perianth, which is narrowed below, transversely wrinkled, and has a thick, eroso-dentate margin. Seed filling the fruit, cotyledons large, plane-convex, radicle small, superior, no endosperm.

THE LEAVES

General external morphological features.—The above description of the leaf agrees well with the external morphological features of the average leaves of the two foreign specimens in the herbarium of the Bureau of Science, particularly the leaves of the specimen from the "Herb. Mus. Paris," collected by M. Le Dr. Thorel in his expedition to Me-Kong, herbarium No. 3192. The other specimen available in the herbarium is from the herbarium of the Canton Christian College, of the Flora of South China with the herbarium No. 136, collected by Levine and Groff from Teng Woo Mountain, Kwong Tung Province, and identified by E. D. Merrill. Outlines of the average form of leaves from the two specimens are shown in text fig. 3, *a–c*.

Internal structure of the leaf.—The transverse section of the blade is also bifacial, and it has the general appearance of that of *Cinnamomum zeylanicum;* but it measures only about 0.140 millimeter in thickness, which is about one-half the thickness of the blade of Ceylon cinnamon (text fig. 3, *e*). The upper and the lower epidermis consist also of single layers of rectangular or quadrangular and highly cutinized cells with very thick cell walls and greatly reduced cavities. The stomata are similar in structure to those of Ceylon cinnamon (text fig. 3, *h*), and the

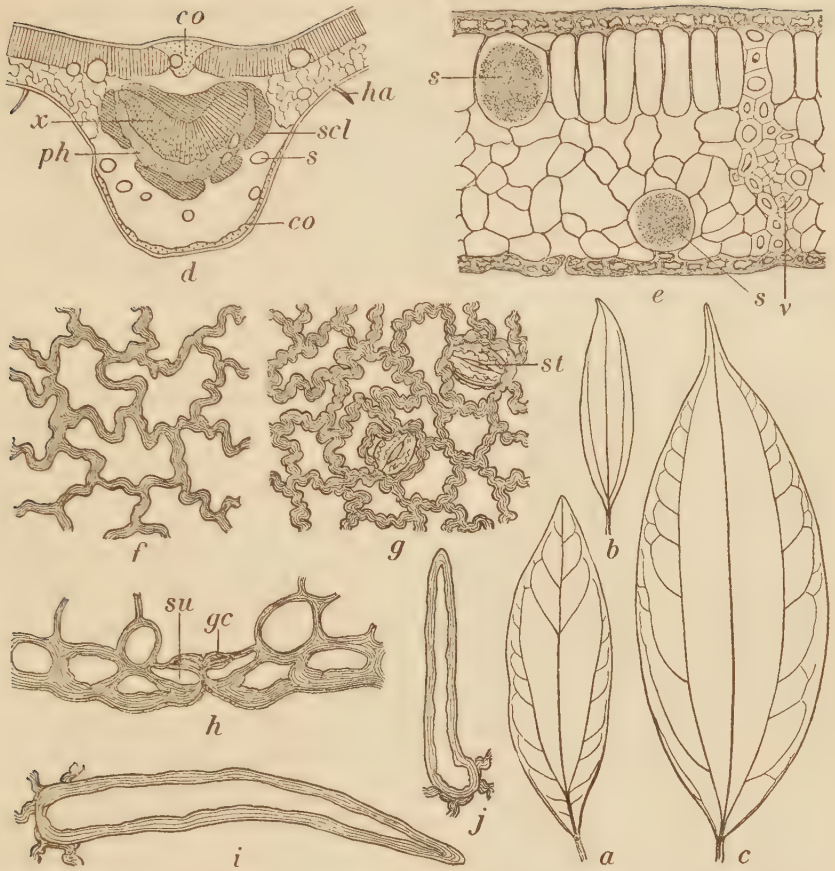

FIG. 3. *Cinnamomum cassia; a, b,* and *c,* three average leaves from the three Chinese specimens in the herbarium, × 0.5; *d,* a diagrammatic representation of a transverse section of the midrib (*co,* collenchyma; *scl,* sclerenchyma; *ph,* phloëm; *x,* xylem; *s,* secretion cells; *ha,* simple hair); *e,* a segment of the transverse section of the blade (*v,* vein; *s,* secretion cell), × 250; *f,* portion of the surface view of the upper epidermis, × 540; *g,* portion of the surface view of the lower epidermis (*st,* stoma), × 540; *h,* a portion of a transverse section of the lower spidermis showing a stoma (*gc,* guard cells; *su,* subsidiary cells), × 700; *i* and *j,* two simple hairs, × 540.

simple unicellular hairs are confined also in the lower epidermis. A single layer of palisade chlorenchyma cells occupies about one-third of the mesophyll, and the individual cell is about 0.05 millimeter long and 0.015 millimeter wide. The secretion cells are ovoid or spheroidal, and are found not only between the palisade cells but also in the lower part of the spongy chlorenchyma region. These secretion cells, like those of *Cinnamomum zeylanicum,* contain yellowish essential oil and rarely mucilage. They are from 0.04 to 0.05 millimeter long and from 0.04 to 0.045 millimeter in diameter. Secretion cells of rounded

form are frequently found in the spongy region, and they are usually smaller in size than those between the palisade cells. The spongy region is fairly well developed, and it consists of irregularly shaped spongy chlorenchyma cells, about 0.03 millimeter long and 0.015 millimeter wide, with large intercellular spaces. The transverse section of the veinlet shows a structure similar to that of the Ceylon cinnamon, but the veinlets of *C. cassia* are smaller and the thick-walled, slightly lignified cells extending from the conducting tissues to the epidermis are usually found in a single vertical row (text fig. 3, *e*).

The transverse section cut through the midrib is slightly convex above and very strongly convex below (text fig. 3, *d*). The upper and the lower epidermis are also composed of single layers of nearly quadrangular cells with greatly cutinized and thickened walls. Just below the upper epidermis there is a narrow group of collenchyma cells which are arranged in wedge shape and bounded at the lateral sides by the palisade cells extended to the upper part of the midrib. Occasionally, one or two secretion cells containing essential oils are found between the collenchyma cells. The collenchyma cells in the inner part of the lower epidermis consist of two or three rows of cells arranged from one side of the midrib to the other.

The meristele is crescent shaped. In the outer part, like that of the Ceylon cinnamon, it is surrounded by an interrupted band of thick-walled, slightly lignified sclerenchyma cells as shown in text fig. 3, *d*. The phloëm region, as usual, is composed of small cells with polygonal outline and confined in the lower part of the xylem region. The xylem region is composed of vessels and wood parenchyma arranged more or less in radial rows. The vessels measure from 0.015 to 0.025 millimeter in diameter. The upper lower part of the meristele is occupied by two groups of parenchyma cells which have small intercellular spaces and contain some starch grains. The endodermis is not conspicuous. The secretion cells, containing essential oil or sometimes mucilage, are usually found scattered in these two parenchyma regions, especially in the lower part and occasionally in the phloëm, mixed with the sieve tubes and companion cells.

Surface preparation.—The upper epidermal cells of *Cinnamomum cassia* in the surface view are also polygonal in outline, like those of *C. zeylanicum* with wavy outline, but they have very much thinner walls. They measure from 0.025 to 0.035 millimeter in their greatest diameter and from 0.01 to 0.02 millimeter in their least diameter. The thickness of their walls is

about 0.003 millimeter. Text fig. 3, *f*, shows the characteristic outline of the upper epidermal cells. The surface view of the lower epidermal cells reveals that they are also polygonal in outline, with strongly wavy walls and with numerous stomata with indistinct outline and some simple unicellular hairs (text fig. 3, *g*). The guard cells, like those of *C. zeylanicum*, are found in depressions, and their exact outline cannot be very well observed. The hairs measure from 0.06 to 0.12 millimeter in length, and they also possess thick walls (text fig. 3, *i* and *j*).

THE BARK

The dried bark or commercial bark.—The bark of *Cinnamomum cassia* Bl. is commonly known in the local market as Chinese cinnamon or "canela de China." It is obtained from the shoots of trees 5 to 6 years old and is often deprived more or less of the greater part of the corky portion. The bark with entire periderm occurs as simple quills not inserted one within another (Plate 5, fig. 20, *a–e*). The individual pieces are from 20 to 30 centimeters long, 10 to 30 millimeters wide, and 1 to 2 millimeters thick. The outer surface is grayish brown with whitish patches; it is uneven and rough, and has some rounded, slightly elevated lenticels and frequently some transversally elongated branch and leaf scars, as represented in the photograph on Plate 5, fig. 20, *c* and *d*.

The commercial cassia bark considered to be the best quality has a general resemblance to the Ceylon cinnamon. It is also usually prepared from shoots 5 to 6 years old and deprived of the greater part of the corky region. The quills are also simple and not inserted one within another. They measure much shorter, but slightly thicker, and are much less straight, even, and uniform than Ceylon cinnamon. The outer surface is rough, darker brown, often with grayish patches due to the imperfect removal of the corky layer by the knife. The inner surface is dark brown, nearly smooth, and faintly striated. The fracture is short and somewhat uneven. The bark is aromatic and has a slightly astringent taste.

Microscopical structure.—The transverse section of the bark of Chinese cinnamon exhibits externally several rows of cork cells; the cells of the outer rows have thin slightly suberized walls and are loaded with a brown substance, while the cells of the inner rows have thick, pitted, nearly colorless walls and also contain a brown coloring matter (Plate 6, fig. 21). The

phellogen is not distinct. The cortical parenchyma, like that of the Ceylon cinnamon, is made up of eight to twelve layers of tangentially elongated or rounded parenchyma cells loaded with starch grains or starch grains mixed with some calcium crystals in raphide form. Small isolated groups of stone cells, with one side thickened and with pitted walls, are scattered in the cortical parenchyma. These stone cells contain either starch grains or a brown substance. The starch sheath is not conspicuous. The middle part of the section of the bark is composed of large, interrupted, sclerenchymatous stone cells with a more-conspicuous one-sided thickening and pitted cell walls. These stone cells, like those of the Ceylon cinnamon, are tangentially elongated or polygonal in outline and they contain minute starch grains, but their walls are thinner and their cavities are larger. They are from 0.04 to 0.12 millimeter long and from 0.02 to 0.06 millimeter wide. In the outer part of the sclerenchyma ring or mixed with the patches of the stone cells are groups of small, thick-walled cells with polygonal outline. These cells correspond to the primary bast fibers or pericyclic fibers. Plate 5, fig. 22, represents a segment of the sclerenchymatous ring illustrating the characters of the stone cells. The inner part of the stone-cell ring is occupied by six to eight layers of parenchyma cells with isolated or small groups of stone cells having thinner walls, and by some secretion cells containing essential oil or mucilage. The parenchyma cells contain minute starch grains, sometimes mixed with calcium oxalate, or sometimes with a large amount of calcium oxalate crystals in raphides only. Like the Ceylon cinnamon the medullary rays are either in a single row or are two rows of cells wide; but the walls of the medullary-ray cells of Chinese cinnamon usually are much thicker and pitted, and those towards the sclerenchyma region are loaded with large amounts of starch grains with some calcium oxalate crystals; while those towards the inner region of the liber contain calcium oxalate crystals in raphide forms. Plate 6, fig. 24, represents a cell drawn from the medullary ray cells towards the inner region of the liber. The calcium oxalate crystals are in raphide forms and measure about 0.028 millimeter in length, while the starch grains are rounded and measure from 0.025 to 0.045 millimeter in diameter.

The bast region has also a general resemblance to that of Ceylon cinnamon, but the bast fibers are much larger in diam-

eter and more or less circular in outline (Plate 6, fig. 23). They measure about 0.03 millimeter in diameter and are usually found in groups of two or four cells arranged in radial rows. The secretion cells containing mucilage are more numerous and larger than those of *C. zeylanicum.* They measure from 0.04 to 0.06 millimeter in diameter. The phloëm parenchyma cells are either circular in outline or tangentially elongated. They are loaded with starch grains or calcium oxalate crystals or both, or sometimes with a brownish substance (Plate 7, fig. 26). The phloëm cells proper, that is the sieve tubes and companion cells, are mostly in a collapsed condition in which the individual cells cannot be distinguished.

The radial section of the bark of Chinese cassia as a whole is very similar to that of Ceylon cinnamon, but much coarser in structure (Plate 6, fig. 25). The secretion cells are prominently larger—about 0.12 millimeter long and 0.05 millimeter wide. The pith rays are comparatively wider and composed usually of about nine rows of cells.

The most conspicuous elements observed in the microscopical examination of the macerated bark are the bast fibers and stone cells. The bast fibers are irregular in outline, shape, length, and diameter. They measure from 0.08 to 0.20 millimeter in length and from 0.005 to 0.015 millimeter in diameter with blunt, pointed, rounded, or truncate ends. Sometimes they are constricted in a certain part and somewhat swollen in another part, as shown on Plate 7, fig. 27, *c.* Occasionally, a transverse view of the medullary rays is observed as indicated on Plate 7, fig. 27, *a* and *b.* The stone cells, as in the transverse and longitudinal sections, are very irregular in shape. They exhibit one-sided thickening, although when the thicker part of the walls of these stone cells happens to be placed towards the upper side and the thinner part towards the lower side as shown on Plate 7, fig. 27, *e,* their walls appear uniformly thickened. The secretion cells are also somewhat prominent because of their size and content. Most of them are more or less ovoid in shape, often isolated but sometimes in groups of two. They are usually empty but in some cases are filled with droplets of yellowish oil (Plate 7, fig. 27, *f*). Few cork cells are observed scattered and intermingled with the stone cells and parenchyma cells; sometimes they have slightly thickened walls (Plate 7, fig. 27, *d*).

CINNAMOMUM MINDANAENSE ELMER

This evergreen tree is found growing extensively in thickets and forests at low and medium altitudes in Mindanao, especially in Surigao and Davao Provinces, where various botanical specimens were collected and from which the original description by Elmer(7) was prepared (Plate 8, figs. 28–31). The species has a close resemblance to *Cinnamomum burmanni* in general appearance. On account of this similarity its specific status is often questioned, and it is sometimes considered to be a variety of *C. burmanni,* which is supposed to have been introduced in the Philippines. Elmer(7) described it as a distinct species, as follows:

A medium sized tree; stem 10 m. high and 3 dm. thick, straight, terete, usually branched from below the middle; main branches ascending, freely branched and ultimately numerous rebranched, forming a dense elongated crown; twigs lax, slender, somewhat drooping, smooth and green, dark brown or blackish in the dry state; wood moderately hard, whitish throughout, odorless and tasteless; bark very smooth throughout, finely mottled with grayish brown and whitish blotches on the epidermis, otherwise cinnamon brown and similar in taste, readily separating into small slabs, nearly 1.5 cm. thick on the stem, only one-half as thick on the larger branches. Leaves opposite or subopposite, scattered along the twigs, the average blades 1 dm. long by 3 cm. wide across the middle or a trifle below it, entire, glabrous, ascendingly spreading, rather numerous, recurved especially toward the acute or acuminate apices, curvingly conduplicate on the upper dark green and semilucid surface, subglaucous beneath, base obtuse or acute and frequently inequilateral, oblong or the smaller ones lanceolate; petiole less than 1 cm. long, frequently only one-half as long, brown in the dry state, glabrous; bud bracts cinerous, 4 mm. long; midrib straight clear into the apex, its basal lateral pair arising some distance above the base and extending two-thirds the length of the blade, the 1 to 3 secondary lateral pairs arising from above the middle and very obscure. Inflorescence divaricate or ascending, averaging 15 cm. long or less, all the stalks smooth and yellowish green, terminal or from the uppermost leaf axils, sparingly branched from beneath the middle; secondary branches only occasionally rebranched, slender, divaricate, bearing at their ends 1 to 2 or even 3 flowers; pedicels similar, 6 to 9 mm. long; perianth in anthesis 6 mm. long, glabrous, the basal one-third united and turbinate; its segments 6 equal, 3.5 mm. long, 2.75 mm. wide, oblong, roundly obtuse at apex, very finely ciliate at least along the margins, veinly in the middle region, glandularly dotted; stamens 12, without glands or even without staminodes, in 2 series opposite the perianth segments; filaments of the outer 6 nearly 2 mm. long, flattened, finely ciliate at the base, those of the inner series less than one half as long; anthers of the outer ones introse, 4-celled, the lower cells larger, lids hanging from the upper ends, 1.25 mm. long, basifixed, truncate at both ends; the inner 6 anthers ovate in outline, only the lower 2 cells present and lateral, hardly extrose; ovary glabrous, 1. 5 mm long, ellipsoid; style 1 mm. longer, also glabrous, bearing

a much enlarged pulverulent stigma; fruits ovately ellipsoid, lucid green with minute whitish spots, when mature shining steel blue and truly ellipsoid, 1.25 cm. long, 7.5 mm. across the middle.

THE LEAVES

General external morphological characters.—The leaves of *Cinnamomum mindanaense* exhibit only slight variation in size and shape. On text fig. 4, *a–d*, four of the outlines of the average forms of leaves of the specimens collected from Misamis, Mount Apo, Davao, Surigao, and Zamboanga are represented.

FIG. 4. *Cinnamomum mindanaense*, average leaves from the different specimens; *a*, a leaf from the specimen from Zamboanga; *b*, from Surigao; *c*, from Misamis; *d*, from a cotype specimen from Mount Apo, Todaya, Davao. × 0.5.

The full-grown leaves are usually from 6 to 15 centimeters long and from 2.5 to 6 centimeters wide at the widest part. They vary from lanceolate to oblong-ovate in outline, petiolate, trinerved or triplinerved, glabrous, slightly coriaceous, dark green and somewhat shining on the upper surface, subglaucous beneath, with entire margin. The base is obtuse or acute and sometimes inequilateral, and the apex acute or acuminate. The petioles are from 8 to 12 millimeters long. The two basal lateral veins, like those of *C. zeylanicum*, may arise at the base and run parallel to the upper part of the midrib up to 6 to 10 millimeters above, or they may apparently arise at about 10 millimeters above the base and pass archwise towards the apex but without reaching it. The transverse veinlets in most cases are not distinct.

Internal structure of the leaf.—A transverse section of the lamina of the leaf of *Cinnamomum mindanaense* has more or less the same general appearance as that of *C. zeylanicum* and *C. cassia* (text fig. 5, *b*). It is, however, thinner than that of *C. zeylanicum,* but slightly thicker than the blade of *C. cassia.* It measures about 0.152 millimeter in thickness. The upper epidermis and lower epidermis consist also of a single layer of cells with thick and highly cutinized cell walls. The stomata closely resembles those of the other two described species, but the guard cells are smaller and mostly in a collapsed condition. They are only found in the lower surface. The simple unicellular hairs are rarely found in the lower surface of the transverse sections. In text fig. 5, *c,* a portion of the lower epidermis is represented showing the detail structure of a stoma, together with the guard cells and subsidiary cells. The palisade region is composed of palisade chlorenchyma cells measuring about 0.05 millimeter in length by 0.011 millimeter in width. The secretion cells are frequently found between the palisade cells. They are either rounded, elliptical, or ovoid; about 0.06 millimeter in vertical diameter and 0.045 millimeter in horizontal diameter, and they are usually filled with yellowish essential oil or are empty. The spongy chlorenchyma region, like that of *C. cassia,* is fairly well developed and made up of irregularly shaped cells with intercellular spaces. Occasionally the secretion cells are found in this region. The veinlets, like the veinlets of *C. zeylanicum* and *C. cassia,* are found at intervals and are also vertically transcurrent by means of thick-walled and polygonal sclerenchyma cells which are arranged in two or more rows.

The midrib in the transverse section is slightly convex above and strongly convex below (text fig. 5, *a*). The upper epidermal cells and the lower ones, like those of the above species, are quadrangular or nearly rounded. Their outer walls are conspicuously thickened and highly cutinized. The cuticle measures about 0.002 millimeter in thickness. The collenchyma region located below the upper epidermis is sometimes more or less fan-shaped in outline and its lower part extends to the sclerenchyma ring of the meristele. It is composed of about seven layers of cells with nearly uniformly thickened walls. The collenchyma cells at the lateral part of the group are arranged in two or three rows and stretched along the inner side of

the epidermis towards the palisade regions. The collenchyma cells in the lower part consist of two or three layers arranged along the inner side of the lower epidermis from one side of the midrib to the other, but without reaching the spongy regions.

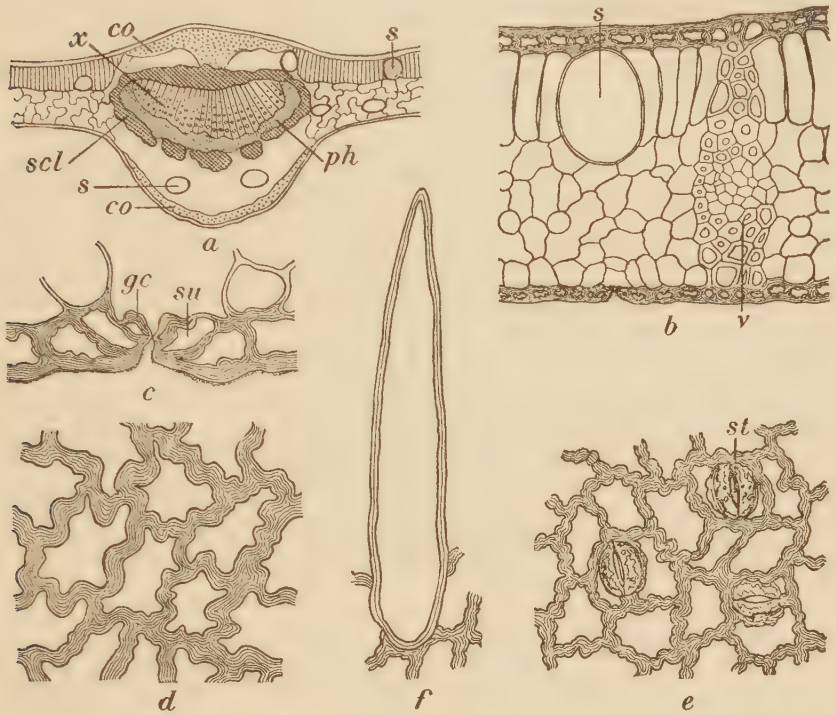

FIG. 5. *Cinnamomum mindanaense; a*, a diagrammatic sketch of a transverse section of the midrib (*co*, collenchyma; *scl*, sclerenchyma; *ph*, phloëm; *x*, xylem; *s*, secretion cell); *b*, a segment of a transverse of the blade (*v*, vein; *s*, secretion cell), × 250; *c*, a portion of a transverse section of the lower epidermis showing a stoma (*gc*, guard cells; *sc*, subsidiary cells), × 700; *d*, a segment of the surface view of the upper epidermis, × 540; *e*, a segment of the surface view of the lower epidermis (*st*, stomata), × 540; *f*, a single hair, × 540.

The meristele is nearly crescent in shape and not conspicuously limited from the cortical parenchyma by an endodermis. The outer region is surrounded by three or four irregular layers of sclerenchyma cells with slight interruptions in the lower part. The phloëm cells are very small and are found only in the lower part of the xylem. The vessels are arranged in radial rows and measure about 0.015 millimeter in diameter. The cortical parenchyma cells are very similar to those of *C. zeylanicum* and *C. cassia*. They also exhibit small intercellular spaces and con-

tain some starch grains or a few crystals of calcium oxalate. Some secretion cells containing essential oil or mucilage are frequently found between the parenchyma cells.

Surface preparation.—The surface view of the upper epidermis is very similar to that of *C. zeylanicum* and of *C. cassia,* except that the epidermal cells have thinner walls and are less wavy than the former, but thicker and more wavy than the latter (text fig. 5, *d*). The epidermal cells measure about 0.03 millimeter in their longest diameter by about 0.02 millimeter in their shortest diameter, and their walls are about 0.004 millimeter thick. The lower epidermal cells, as usual, are smaller than the upper ones, and their walls are thinner and more wavy in outline (text fig. 5, *e*). They measure about 0.02 millimeter in their longest diameter and 0.015 millimeter in their shortest diameter. The stomata are also confined to the lower epidermis and they are found below the level of the ordinary epidermal cells. Their outlines are not very distinct, and they are very much smaller than the stomata of the two species described above. The simple unicellular hairs are not numerous and they have thinner walls, but they are larger and longer than those of *C. zeylanicum* and *C. cassia.* They are about 0.12 millimeter long and 0.018 millimeter wide (text fig. 5, *f*).

THE BARK

The external features of the fresh bark of *Cinnamomum mindanaense* are given by Elmer(7) in his description quoted above for the plant.

The commercial bark.—The dried bark of *C. mindanaense* occurs in the market with or deprived of the greater part of the corky portion. It appears very similar to the commercial bark derived from *C. cassia.* In fact, for some time, it has been suspected that the dried bark of *C. mindanaense* is being sold in this country by retail stores as "Chinese cinnamon," the bark derived from *C. cassia.* The commercial bark from *C. mindanaense,* however, occurs either in simple or in a few overlapping quilled pieces measuring from 50 centimeters to 1 meter in length and 6 to 8 centimeters in width. These pieces of bark are probably prepared from either the main stem or branches from 6 to 10 years old, deprived of their suberous coat and frequently inserted one within another. Each side of the quill is made to curl inward like that of *C. zeylanicum* to form a channel with incurving sides, which makes the entire structure a somewhat flattened cylinder about 4 to 5 centimeters in dia-

meter (Plate 9, fig. 34, *a–f*). The thickness of the individual quill varies from 1 to 3 millimeters. The outer surface may be rough or smooth, but it is less smooth than the outer surface of the cassia bark and usually darker brown or similar in color; often with transverse markings and large branch scars. Longitudinal striations like those found on the outer surface of *C. zeylanicum* are not observed. Sometimes patches or portions of the corky region are found on the outer surface. This is perhaps due to carelessness in the peeling of the suberous coat. The inner surface is dark brown and somewhat longitudinally striated. The fracture is short and brittle, and the fracture surface is smoother or more even than that of cassia bark. It is aromatic like cinnamon bark, and the taste is also astringent.

The dried bark with suberous coat is considered of inferior quality. It also occurs either as simple or few overlapping quills (Plate 9, fig. 34, *f*). The outer surface is grayish brown with grayish-white patches of lichens, rough with longitudinal shallow fissures, and prominent tangentially elongated stem scars. The inner surface is also dark brown.

Microscopical structure.—The structure of the periderm of a transverse section of the bark of *Cinnamomum mindanaense* is very similar to that of *C. cassia*. The cork cells are also slightly suberized and some have thick walls, which usually contain a brown substance. The cortical parenchyma is made up of several layers of slightly thick-walled, pitted and tangentially elongated cells which sometimes contain a brown substance. A few secretion cells are usually found between the parenchyma cells. These, like those observed in the other species described, contain yellowish essential oil and sometimes mucilage. Some stone cells, in small isolated groups, are intermingled with the parenchyma cells. These stone cells have thinner walls than those found in the middle region of the section, with one side of their walls thicker than the other and pitted. The pericyclic region consists of interrupted, large, polygonal and tangentially elongated, or irregularly shaped stone cells with a distinct one-sided thickening and pitted cell walls like those of *C. cassia* (Plate 10, fig. 35). They measure 0.04 to 0.12 millimeter in length by 0.02 to 4 millimeters in width. Unlike those of the other species described above, they are not usually loaded with starch grains except some of those found towards the bast region. The small groups of primary pericyclic fibers in the outer part of the stone-cell ring are not usually observed. This ex-

plains why the outer surface of the peeled bark does not show the longitudinal striation as does the bark of *C. zeylanicum*. The inner part of the stone-cell ring consists of tangentially elongated parenchyma cells with slightly thickened and pitted walls, and of groups of stone cells. Intermingled with the parenchyma and stone cells there are secretion cells containing mucilage or essential oil, which are also tangentially elongated. They measure about 0.08 millimeter in length and 0.04 millimeter in width. The middle region is composed of radiating groups of sclerenchyma cells mixed with a few bast fibers (Plate 10, fig. 36). These groups of sclerenchyma cells and bast fibers are separated either by tangentially elongated parenchyma cells, or by somewhat tangentially elongated medullary-ray cells two or three cells wide. The sclerenchyma cells and bast fibers have polygonal outlines and sometimes are tangentially elongated. Some of them are filled with starch grains or with a few prismatic crystals of calcium oxalate.

The bast region occupies about three-fourths of the thickness of the bark. It is characterized by the absence of the bast fibers as indicated on Plate 10, fig. 37, and by the presence of the numerous secretion cells, most of which contain mucilage and some essential oil. The phloëm cells are in groups, interrupted by the phloëm parenchyma and secretion cells and traversed by the medullary rays. They are nearly collapsed and have wavy outlines. The phloëm parenchyma cells have rounded or polygonal outlines sometimes tangentially elongated, while the secretion cells are usually rounded and empty. The medullary rays are one to three cells wide with slightly thickened and pitted walls. They usually contain prismatic calcium oxalate crystals, and those towards the periphery contain starch grains.

In the radial section the cortical and pericyclic parenchyma, the stone cells, and the secretion cells appear somewhat rounded or polygonal in outline, as shown on Plate 10, fig. 38. The sclerenchyma cells mixed with the bast fibers, on the other hand, appear slightly elongated. They have thick and pitted cell walls and their two ends are not pointed, while those of the bast fibers are pointed, as illustrated on Plate 11, fig. 40. On the same plate, fig. 41 is a portion of the radial section cut through the phloëm region. It is characterized by the fifteen rows of medullary cells filled with calcium oxalate crystals, and by the axially elongated secretion cells measuring from 0.06 to 0.25 millimeter

in length and 0.025 to 0.03 millimeter in width. The sieve tubes are quite evident by their transverse walls and content.

The powder.—The powder is yellowish brown to dark brown and has a strong aromatic odor very similar to that of *Cinnamomum zeylanicum*. Under the microscope the powder of *C. mindanaense* exhibits a great assemblage of the various kinds of tissues observed in the different sections described above (Plate 11, fig. 42, *a–h*). The stone cells appear very numerous and diversified in shape. They are observed singly or in groups, irregular, colorless or containing a reddish-brown granular substance, with uniformly thickened walls or one side thinner than the other. The bast fibers are quite prominent and are either fragmentary or entire, with thick or thin, slightly lignified walls and are spindle shaped. They are from 0.06 to 0.25 millimeter long and 0.005 to 0.01 millimeter wide. The starch grains may be simple or compound, rounded or polygonal, and are about 0.006 millimeter in diameter. The secretion cells are not conspicuous and they are usually found in the fragmentary form, but sometimes are observed entire, as represented on Plate 11, fig. 42, *h*. They appear like ordinary parenchyma cells, except that when treated with Soudan red in glycerin their walls become somewhat red. The medullary-ray cells are often identified in the larger fragments. They are characterized by their content, consisting of either numerous starch grains or calcium oxalate crystals. They may be in radial or tangential view. The sieve tubes and companion cells cannot be easily distinguished. The cork cells are occasionally observed, while the parenchymatous cells, in fragments or entire, singly or in groups, are very conspicuous.

Similar types of tissues are observed in the macerated section by Schultze's process; namely, the stone cells, bast fibers, parenchyma cells, etc.; but in this preparation the secretion cells are very conspicuous. They appear in large numbers, with ovoid or greatly elongated cells measuring .0045 to 0.17 millimeter in length and 0.02 to 0.03 millimeter in diameter (Plate 11, fig. 42, *i*). They usually contain droplets of yellowish oil or a somewhat yellowish white granular substance, or in some cases are empty.

CINNAMOMUM MERCADOI VIDAL

This large endemic tree is widely distributed in forests at low and medium altitudes from Babuyan Islands and northern

Luzon to Mindanao (Plate 12, figs. 43–51). It is commonly known as *kalĩngag* and, like the other species described above, is variable in height and in the shape, size, and texture of the leaves. This is especially evident among the plants growing at higher altitudes. It was originally described by S. Vidal(22) as follows:

Arbor ramulis striatis, radicis cortice subcamphorata, ramorum cortice fere inodora. Petioli fusci, slutaceo-rugosi, complanati, ad 1 cm. longi. Folia e basi cuneata, oblonga vel lanceolato-oblonga, apice longe obtuso-acuminata, longa, 7-12 cm. lata 2-4 cm., coriacea, margine increassato-revoluta, supra nitida subtus opaca, glabra, triplinervia praeter nerves basilares tenuissimos interdum praesentes, obsolete transverse venose vel avenia; nervis-lateralibus usque apicem fere attingentibus, usque ⅔ supra prominulis, apice evanescentibus. Paniculae foliis longiorae; pedunculis striatis, sub-angulatis; floribus mediocribus, ad 5 mm. longis, pedicellatis, perianthio cano-pubescente, profunde lobato, lobis sub-rotundatis, Bacca perianthio accrescente, striato, usque medium cincta; oblonga, interdum leviter apiculata, circ. 15 mm. longa.

Elmer(8) gives the following additional field information:

Field note:—Tree 50 feet high, with a 2 feet thick bole; wood soft, white and with yellowish streaks, with a strong green cinnamon odor, light, tasteless; bark comparatively thick, gray, rigid; young twigs green; leaves chartaceous, darker green on the upper curvingly conduplicate side; inflorescence terminal and subterminal, ascending or erect, yellowish or pale green; flowers slightly odorous, of the same color as the stalks except the deeper yellow anthers. "Caningag" is the Bagobo name. As soon as the tree was cut a sweet aromatic odor was detected and soon afterwards the woods in that vicinity were filled with it.

THE LEAVES

General external morphological characters.—The full-grown leaves vary according to the altitude at which the plants grow; for instance, those collected from an altitude between 5,000 and 8,000 feet measure from 5 to 10 centimeters in length by 2 to 5 centimeters in width, while in material collected at low and medium altitudes the leaves measure from 10 to 18 centimeters in length by 5 to 8 centimeters in width (text fig. 6, *a–h*). They vary also in form, from lanceolate to oblong-ovate, petiolate, trinerved, or triplinerved coriaceous, glabrous, dark green and shining on the upper surface. The lower surface is lighter green and may be glabrous or slightly pubescent. The margin is entire and slightly deflexed downward or revolute. The base is obtuse or acute and the apex acute or acuminate. The petioles are from 7 to 18 millimeters long, somewhat cylindrical,

and have shallow grooves on the upper part. The two primary lateral veins usually arise directly from the base, or sometimes at a distance of about 1 centimeter above the base, and pass arch-wise towards and near the apex, but as in *C. zeylanicum* without reaching it. The transverse veinlets, except the lateral ones, are usually inconspicuous and in a very few cases are distinct and reticulately arranged.

FIG. 6. *Cinnamomum mercadoi*, average leaves from specimens from various parts of Luzon; *a* and *d*, from Rizal; *b*, from Laguna; *c*, from Isabela; *e*, from Bontoc; *f*, from Benguet; *g*, from Mount Umingan; *h*, from Mount Bulilao, Capiz. × 0.5.

Internal structure of the leaf.—The transverse section of the blade of a full-grown leaf is also bifacial, measuring from 0.16 to 0.44 millimeter in thickness (text fig. 7, *b*, *c*, and *d*). The upper epidermis as well as the lower epidermis is also composed of a single layer of cells. The upper epidermal cells, like the corresponding epidermal cells of the other species described, are

more or less rectangular in outline with very thick and highly cutinized cell walls, but thinner than those of *C. zeylanicum*, and measure about 0.015 millimeter in thickness. The lower epidermal cells, however, at least in some of the specimens examined, differ from those of the other specimens in that they are sometimes papillous in character. This is true of the lower epidermal cells of the leaves of herbarium specimens *20233* and *46783*, as shown in text fig. 7, *d* and *e*. On the same text figure, *b*, a cross-section of the blade from a full-grown leaf taken from the cotype specimen *2459*, shows the normal type of lower epidermal cells. On account of this variation it is questionable or, rather, interesting to know whether this papillous character is inherent to the plant or whether these specimens having papillous epidermal cells belong to another species. An enlarged portion of the cross-section of the lower epidermis with normal cells and cut through a stoma is represented on text fig. 7, *e*, while a corresponding section from a cross-section of the lower epidermis with papillous cells is shown as fig. 7, *f*. The simple unicellular hairs are seldom found on the leaf with normal epidermal cells, but they are found to be numerous in the specimens with the papillous type of lower epidermis. The hairs and the stomata, as in the other species described above, are confined to the lower surface only. The stomata are also sunken and show the same characteristics and structure as those of *C. zeylanicum*. The guard cells are depressed and overarched by subsidiary cells, which are arranged parallel to the pore. The palisade cells measure about 0.05 millimeter in length and about 0.012 millimeter in diameter. They consist mostly of a single layer, but sometimes a secondary layer, consisting more or less of loosely arranged short palisade cells, is observed. They measure about 0.03 millimeter in length. The secretion cells are usually located below the upper palisade layer. They are either rounded polygonal or somewhat ovoid in outline. They contain frequently yellowish green essential oil, and they measure from 0.05 to 0.06 millimeter in their vertical diameter and from 0.03 to 0.05 millimeter in their horizontal diameter (text fig. 7, *b*, *c*, and *d*). The spongy region occupies a greater portion of the mesophyll, with regular-sized intercellular spaces, and occasionally one or two secretion cells are found in the lower region. The veinlets occur also at intervals along the section, most of which are cut obliquely. The transverse sections of the veinlets appear very similar to those of the other species. They are

also vertically transcurrent on both sides by means of polygonal sclerenchyma cells arranged in a single vertical row.

A transverse section cut through the midrib is convex above and broadly convex below (text fig. 7, *a*). It is quite similar to that of *C. zeylanicum* except that it is smaller. The upper and lower epidermis consist of single layers of nearly quadrangular,

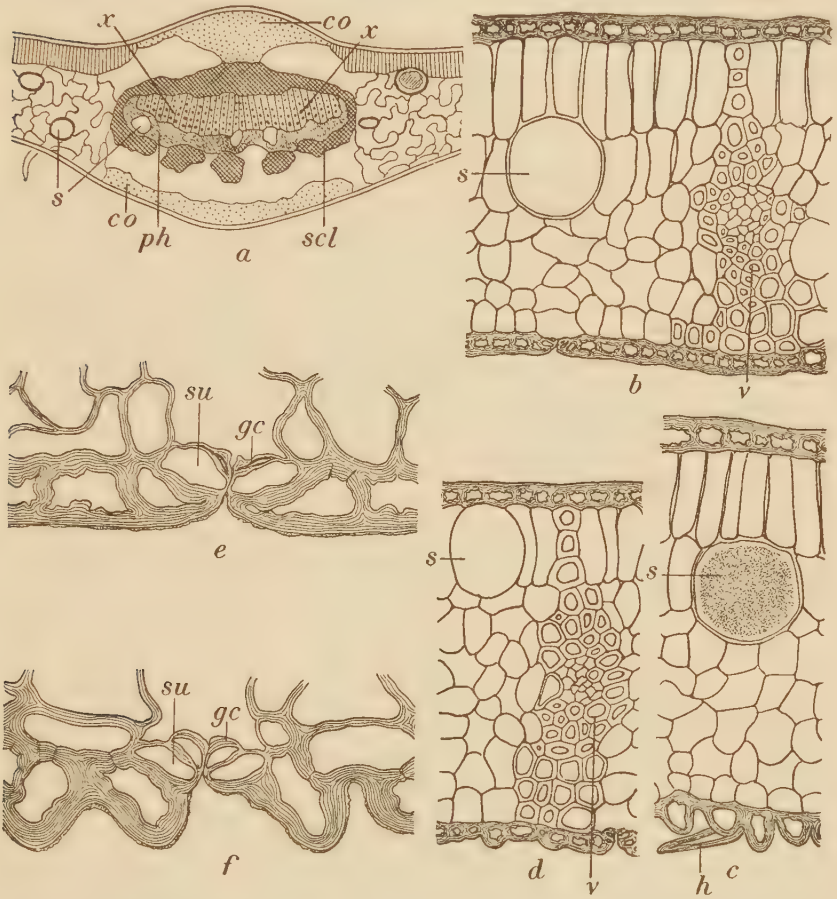

FIG. 7. *Cinnamomum mercadoi; a*, a diagrammatic sketch of a transverse section of the midrib (*co*, collenchyma; *scl*, sclerenchyma; *ph*, phloëm; *x*, xylem; *s*, secretion cell); *b*, a segment of a transverse section of the blade from a cotype specimen, *2459* (*v*, vein; *s*, secretion cell), × 250; *c*, a segment of a transverse section of the blade of specimen *4678*, showing papillous type of lower epidermal cell (*h*, hair), × 250; *d*, a segment of a transverse section of the blade from specimen *20933*, × 250; *e*, a portion of a transverse section of the lower epidermis showing a stoma (*gc*, guard cell; *su*, subsidiary cell), × 700; *f*, a portion of a transverse section of the lower epidermis of specimen *46783*, showing also a stoma (*gc*, guard cells; *su*, subsidiary cells), × 700.

highly cutinized cells with greatly reduced cavities. The upper collenchyma region is also fan-shaped like that of the Ceylon cinnamon while the lower portion is extended to the sclerenchyma ring, while the lateral sides extend to the palisade regions. The lower collenchyma region extending along the inner side of the lower epidermis consists of two or three layers of cell. The parenchyma cells around the conducting tissues have thin walls, are nearly round in outline, and have very small intercellular spaces. Sometimes they are filled with starch grains and frequently two or more secretion cells are found between them. The meristele is not sharply limited from the parenchyma cells by endodermis. In the outer part around the conducting tissue, there are two or three rows of thick-walled sclerenchymatous cells with three or four slight interruptions in the lower part. The conducting tissues are grouped more or less in a lenticular form with the phloëm region confined to the lower side only. Very often between the phloëm cells there are secretion cells containing either essential oil or mucilage. The water-conducting cells are arranged in radial rows and their average diameter is about 0.018 millimeter.

Surface preparation.—The upper epidermal cells appear in the surface sections as polygons measuring about 0.035 millimeter in their longest diameter and about 0.025 millimeter in their shortest diameter (text fig. 8, *b*). They have very thick and highly cutinized and wavy walls about 0.008 millimeter in thickness. The walls of the upper epidermal cells of *C. mercadoi* are about as thick as those of *C. zeylanicum* or slightly thicker and are sometimes faintly striated. The lower epidermal cells are also polygonal in outline, and measure about 0.02 millimeter in length and about 0.01 millimeter in width (text fig. 8, *b*, *c*, and *d*). Their walls measure about 0.004 millimeter in thickness and are not as much convoluted as those of *C. zeylanicum* or *C. cassia*. The stomata are larger than those of *Cinnamomum zeylanicum*, *C. cassia*, or *C. mindanaense*. The guard cells are clearly visible with two distinct, large neighboring cells at the sides. The hairs are simple, unicellular, and have very thick walls. They vary in length from 0.1 to 0.3 millimeter and are about 0.015 millimeter wide (text fig. 8, *c* and *f*). These hairs are only found on the lower epidermis of the leaves that have the papillous type of epidermal cells. They may be straight or wavy in outline.

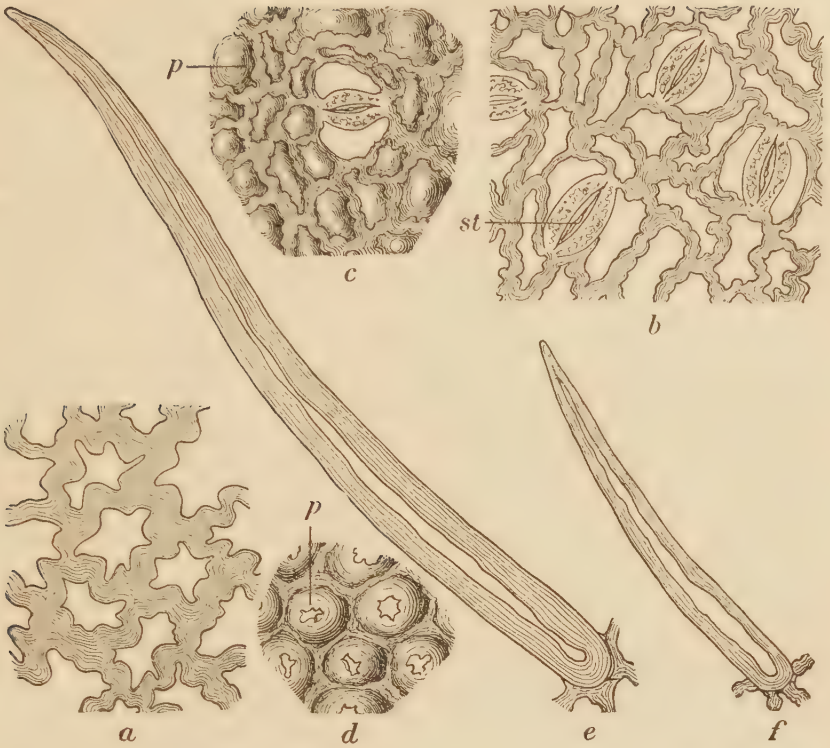

FIG. 8. *Cinnamomum mercadoi; a*, a portion of a surface view of the upper epidermis, × 540; *c*, a portion of a surface view of the lower epidermis (*st*, stoma), × 540; *c* and *d*, portion of the surface view of the lower epidermis of specimen *46783* (*p*, papilla), × 540; *e* and *f*, simple hairs, × 540.

THE BARK

The old bark.—The bark from a large trunk measures from 8 to 15 millimeters in thickness. The outer surface is dark brown and sometimes greenish brown with grayish patches of lichen or greenish shadings due to the presence of lower forms of algæ. It is uneven, rough, and sometimes scaly due to the irregular longitudinal and transversal fissures. The scales of the suberous coat are not easily separable. The middle part is also granular as in the other species and more or less fibrous. The fracture is somewhat tough, and the fracture surface is nearly even in the outer part but slightly splintery in the inner part.

The younger bark is much thinner and usually measures from 4 to 7 millimeters in thickness (Plate 13, fig. 52, *a–c*). The external part is also grayish brown or dark brown, with some

yellowish green patches of lichens or algæ. It may be smooth or rough with numerous elevated lenticels. These lenticels are sometimes observed arranged in groups. They may be rounded or axially elongated. The middle region of the bark is also slightly granular. The inner surface when fresh is creamy white and gradually becomes dark with longitudinal fine striations. The pieces of bark when dried appear flat or slightly quilled. The fracture is short, and the fracture surface is even towards the corky region and uneven toward the phloëm region. The odor is aromatic like that of sassafras, and the taste is slightly astringent and sweetish.

Occasionally the bark of *C. mercadoi* is sold in the market like that of *C. mindanaense* deprived of most of the suberous coat and cortical parenchyma. The bark is observed in simple quills nearly flat and about 4 millimeters in thickness and the pieces of bark are not arranged one within another. The outer surface is dark brown, smooth or rough, with a few patches of the periderm in some places. The inner surface is nearly smooth and also longitudinally striated. The structure of the transverse section of the bark of *C. mercadoi* has a general resemblance to that of *C. cassia,* both have a coarse structure, but the latter is distinguished from the former by the type of its calcium oxalate crystals, secretion and stone cells, and odor.

Microscopical structure.—The outer suberous coat consists of several layers of tangentially elongated and radial rows of closely fitted and slightly suberized cork cells. Intermingled between the thin-walled cork cells there are layers of short pitted stone cells with one-sided thickening, as indicated on Plate 14, fig. 53. The cortical parenchyma is composed of eight to fourteen layers of tangentially elongated parenchyma cells which contain usually minute and rounded starch grains. Occasionally, between these parenchyma cells there are some secretion cells containing essential oils or mucilage, like those of the other species above. Sometimes some minute calcium oxalate crystals, in raphides or clinorhombic forms, are found mixed with the starch grains in some parenchyma cells. Very often a few groups of thin-walled stone cells are scattered in the cortex. The starch sheath, as usual in the other species, is not conspicuous.

The middle region of the section of the bark of *C. mercadoi* has a great similarity to the structure of the middle part of *C. cassia,* except that the stone cells are larger (Plate 14, fig. 54). These stone cells are tangentially elongated and they

measure from 0.06 to 0.10 millimeter in length by 0.06 to 0.82 millimeter in width. They are observed in groups arranged in an interrupted ring around the bark. Sometimes, as in the middle part of the bark of *C. zeylanicum,* small groups of sclerenchyma cells are found in the outer part of the stone-cell ring or partly mixed with the stone cells. The inner portion of this region, as that of the other barks, consists of several layers of parenchyma cells, polygonal in outline, and filled with minute starch grains or calcium oxalate crystals or both (Plate 14, fig. 55). Scattered between the parenchyma cells there are also some stone cells with thinner walls. These stone cells have larger cavities and exhibit also a conspicuous one-sided thickening. Between the stone cells, or between the parenchyma cells, secretion cells containing either mucilage or essential oils are present. Like the innermost part of the middle region of *C. zeylanicum* the parenchyma cells are smaller and distinctly polygonal in outline, most of them are also filled with starch grains or calcium oxalate crystals or both (Plate 14, fig. 56). This part is traversed by medullary rays which are two cells wide. The medullary-ray cells are larger than the corresponding medullary-ray cells of the other species described above. They are radially elongated and loaded also like the parenchyma cells of *C. cassia* with starch grains and calcium oxalate crystals.

The bast region is characterized by the presence of a larger number of bast fibers and parenchyma cells, loaded with a brownish substance instead of starch grains like those of *C. cassia* (Plate 14, figs. 56–58). The bast fibers are larger than the corresponding bast fibers of *C. zeylanicum,* but almost the same size as those of *C. cassia.* They are tangentially elongated and usually radially or tangentially arranged. The phloëm cells are mostly collapsed into strands, the cell cavities of which are scarcely visible. The secretion cells towards the cambial region are conspicuous for they contain distinct droplets of yellowish essential oil and they are rather numerous. The mucilage-containing secretion cells, however, are fewer but larger than the oil-containing secretion cells. They are readily distinguished from the latter because they are usually empty. The bast region is traversed by medullary-ray cells which are two cells wide; these are either loaded with a brownish substance or calcium oxalate crystals in raphide or fusiform shape as represented on Plate 14, figs. 57 and 58.

The cortical parenchyma cells and the stone cells from the middle portion of the radial section, appear more or less polygonal in outline, while the parenchyma cells of the inner region exhibit slight axial elongation. The bast fibers are spindle shaped, greatly elongated, and found either singly or in groups as in the transverse section. On Plate 14, fig. 59, a radial section, cut through the bast region is indicated. The medullary rays are from eight to twelve cells wide. As in the transverse section of the medullary ray, the cells appear loaded with minute starch grains or calcium oxalate crystals in raphides or clinorhombic forms and sometimes those in the inner part are filled with a brownish substance only. The secretion cells are prominent in the longitudinal section. They are as a rule axially elongated, but those towards the outer region are somewhat rounded or nearly elliptical. They may or may not contain droplets of essential oil or mucilage and measure from 0.05 to 0.1 millimeter in length and about 0.05 millimeter in width. Occasionally they occur among the medullary-ray cells as illustrated on Plate 14, fig. 59. The phloëm cells are not conspicuous; as they are collapsed into strands, their structure is rather obscure. In some cases, however, because of their characteristic tranverse walls, they become recognizable. The calcium oxalate crystals in raphides are also found in the phloëm parenchyma. They measure about 0.012 millimeter in length and about 0.001 millimeter in their greatest diameter. On Plate 15, fig. 60, is a transverse section of parenchyma cell containing many calcium oxalate crystals in raphides form.

In the preparation from the material macerated by Schultze's process, as in the other species, the most prominent tissues observed are the bast fibers, measuring from 0.08 to 0.25 millimeter, isolated or in groups, straight or somewhat crooked with sometimes a slight reduction in diameter in the middle part (Plate 15, fig. 61, *a*); the stone cells, which exhibit a diversity of forms with larger or small cavities and with thick or thin pitted cell walls (Plate 15, fig. 61, *b*); the secretion cells, which vary from 0.02 to 0.10 millimeter in length and from 0.012 to 0.022 in width, appear either empty or filled with droplets of yellowish essential oil or with mucilage, as indicated on Plate 15, fig. 61, *g;* the cork cells and the slightly lignified parenchyma cells have thicker walls. The mucilage-secretion cells are often observed swelling up and becoming

irregularly shaped with droplets of essential oil (Plate 15, fig, 61, *c*).

CINNAMOMUM INERS REINWARDT

According to Flückiger and Hambury(9) *Cinnamomum iners* is another decidedly variable species occurring in continental India, Ceylon, Tavoy, Java, Sumatra, and other islands of the Indian Archipelago, and possibly, in the opinion of Thwaites,(20) it is a mere form of *C. zeylanicum*. Meissner,(15) however, states that *C. iners* can be well distinguished by its paler and thinner leaves, its nervation, and the character of its aroma (Plate 16, figs. 61–65).

In the Philippines this species has been reported as occurring in Mindoro, Palawan, Samar, Mindanao, Tawi-Tawi, and Rizal, Luzon. The dried bark is occasionally sold as cinnamon.

Cinnamomum iners is a small to large tree with usually gray, smooth bark and sometimes with horizontal, wavy annular thickening. The leaves are opposite, petiolate, glabrous, coriaceous, trinerved, shining above and glaucous below, and vary in outline from lanceolate to oblong or linear oblong-ovate and from 8 to 20 centimeters in length. The apex is acute or acuminate, and the base may be rounded, obtuse, or acute. The inflorescence is paniculate, long peduncled and silky pubescent; the flowers small, about 4 millimeters long, with persistent perianth lobes. The fruit is ovoid in shape, and about 1 centimeter long; the base of which is sunk in the perianth (Plate 16, figs. 62–66).

THE LEAVES

General external morphological features.—As indicated above and illustrated in text fig. 9, *a–h*, the full-grown leaves exhibit great diversity in size and form. They measure from 8 to 21 centimeters in length by 2.5 to 9 centimeters at the widest part. The largest leaf is that from Java measuring 21 centimeters in length by 8.5 centimeters at the widest part (text fig. 9, *a*); next is that from Camp Kithley, Lake Lanao, Mindanao, which is 20.5 centimeters long by 6.5 centimeters wide (text fig. 9, *b*); the smallest also came from Camp Kithley, Lake Lanao, and measures about 10 centimeters in length and 2.2 centimeters at the widest region (text fig. 9, *f*). The leaf is lanceolate or linear oblong to oblong-ovate, petiolate, coriaceous, trinerved, glabrous and shining above, and glaucous below with

entire margin. The base is rounded, obtuse or acute, sometimes inequilateral, and the apex acute or acuminate. The petiole is from 9 to 12 centimeters long and slightly like that of *C. zeylanicum*. The midrib runs straight clear into the apex, its basal lateral veins arise either directly or about 8 millimeters above the base and extend arch-wise towards the tip. In large leaves the midrib does not reach the tip. The secondary veins as in the other species are not distinct, except in a few cases and those at the lateral part of the two basal primary veins.

Internal structure of the leaf.—The transverse section of the blade of the leaf of *C. iners* has a great similarity to the trans-

FIG. 9. *Cinnamomum iners*, average leaves from specimens from the Philippines and from abroad; *a*, from Java; *b*, from Camp Kithley, Lake Lanao, Mindanao; *c*, from Eil Simaloer bij., Sumatra; *d*, from Res. Palembang, Sumatra; *e* and *h*, from Catubig River, Samar; *g*, from herb. L. Pierre *6170*. × ⅓.

verse sections of those of the other species described above, particularly to that of *C. zeylanicum*, but it is much thinner than the latter and is more hairy (text fig. 10, *b*). The upper and the lower epidermis are made up of almost the same size and shape of cells as those of the Ceylon cinnamon, with thick walls and large cavities. The palisade chlorenchyma cells are wider and shorter, measuring about 0.06 millimeter in length and 0.015 millimeter in width. The secretion cells are not so numerous, and they are usually elongated, about 0.054 millimeter long and 0.029 millimeter wide, and contain yellowish essential oil. They are mostly found, as in *C. zeylanicum* and *C. min-*

danaense, in the palisade region. The spongy chlorenchyma is composed of large irregularly shaped cells with moderate sized intercellular spaces. They occupy about two-thirds of the thickness of the mesophyll. The veinlets are also found at intervals, and most of them are cut obliquely. They are strongly developed and are stretched out vertically from the upper to the lower epidermis by means of thick-walled polygonal sclerenchyma cells. At the lateral part they are usually bounded with one or two layers of thick-walled cells. In the upper region the xylem is connected with the upper epidermis by two or three vertical rows of thick-walled cells and the lower part, the phloëm region, is connected with the lower epidermis by means of three or four rows of cells which are also thick-walled like those of *C. zeylanicum.* The stomata are very similar to those of *C. zeylanicum* and the other described species and they are also confined to the lower surface. A portion of the lower epidermis, showing the structure of a stoma, is represented in text fig. 10, *c.* The hairs, as in the other species, are only found in the lower epidermis; and they are also simple, unicellular, and have thick walls. They are, however, much more numerous and longer than those of the other species of cinnamon. They measure from 0.1 to 0.2 millimeter in length and about 0.012 millimeter in diameter (text fig. 10, *f* and *g*).

The midrib in the transverse section is slightly convex above and somewhat strongly convex below, as indicated in text fig. 10, *a.* The upper and the lower epidermis consist of a single layer of nearly quadrangular thick-walled and highly cutinized cells. The sclerenchyma region in the upper part is rather poorly developed, although in some specimens is a fan-shaped structure like that of Ceylon cinnamon. It consists of two to three layers of cells extending from the palisade region of one side to the other. The collenchyma region in the lower part consists of a narrow strip of three or four layers of cells, and stretches out from one side of the midrib to the other, connecting the two spongy regions. The cortical parenchyma in the upper part of the meristele consists of a few layers of thin-walled parenchyma cells, while that of the lower part consists of about seven to eight layers of cells, some of which contain a brownish substance. Scattered in the cortical parenchyma there are some secretion cells of the same type as those of the other species, except that they are more numerous in this species. The meristele, as usual, is not limited by a distinct endodermal or starch sheath. The conducting tissue is more or

less plano-convex in outline, surrounded by an sclerenchyma ring with one or two narrow interruptions below. The sclerenchyma ring consists of three or four layers of thick-walled and slightly lignified cells. The vessels are arranged in radial rows and measure from 0.015 to 0.033 millimeter in diameter. The phloëm region as in the other species of cinnamon is confined to the lower part only. Some secretion cells are often found mixed with the sieve tubes.

Surface preparation.—The upper epidermal cells appear very similar to those of the *C. zeylanicum*, but they have slightly thinner walls which are about 0.005 millimeter thick with sometimes a very faint striation (text fig. 10, *d*). The epidermal cells are polygonal in outline with greatly undulated cell walls. They measure from 0.03 to 0.04 millimeter in their longest diameter and from 0.017 to 0.03 millimeter in their shortest diameter. The lower epidermal cells are similar to the epidermal cells of the other described species of cinnamon (text fig. 10, *e*). They are also polygonal in outline but with less-convoluted cell walls. They measure from 0.02 to 0.035 millimeter in their longest diameter and from 0.01 to 0.02 millimeter in their shortest diameter. The stomata are numerous and are found in depressions with indistinct outlines. The hairs are very numerous, simple, and unicellular. They measure from 0.011 to 0.180 millimeter in length. They may be straight, bent, or wavy in outline.

THE BARK

The only piece of bark of *Cinnamomum iners* available during the investigation was that taken from herbarium specimen *6264*, collected by the late Dr. C. F. Baker, from Impolutao, Bukidnon, Mindanao (Plate 19, figs. 75, *a* and *b*). This piece of dried, slightly quilled bark is about 9 centimeters long, 2.5 centimeters wide, and about 6 millimeters thick. The external part is light brown with grayish white and yellowish green patches of lichens or algæ. It is uneven and rough, with some slightly elevated, rounded or oblong lenticels and with transverse and longitudinal fissures on one side. The middle part is somewhat granular, reddish brown, and fibrous towards the inner part. The fracture is tough, and the fracture surface is uneven and slightly splintery in the inner region. The odor is aromatic, more or less like that of the sassafras and the taste is astringent, slightly pungent and aromatic.

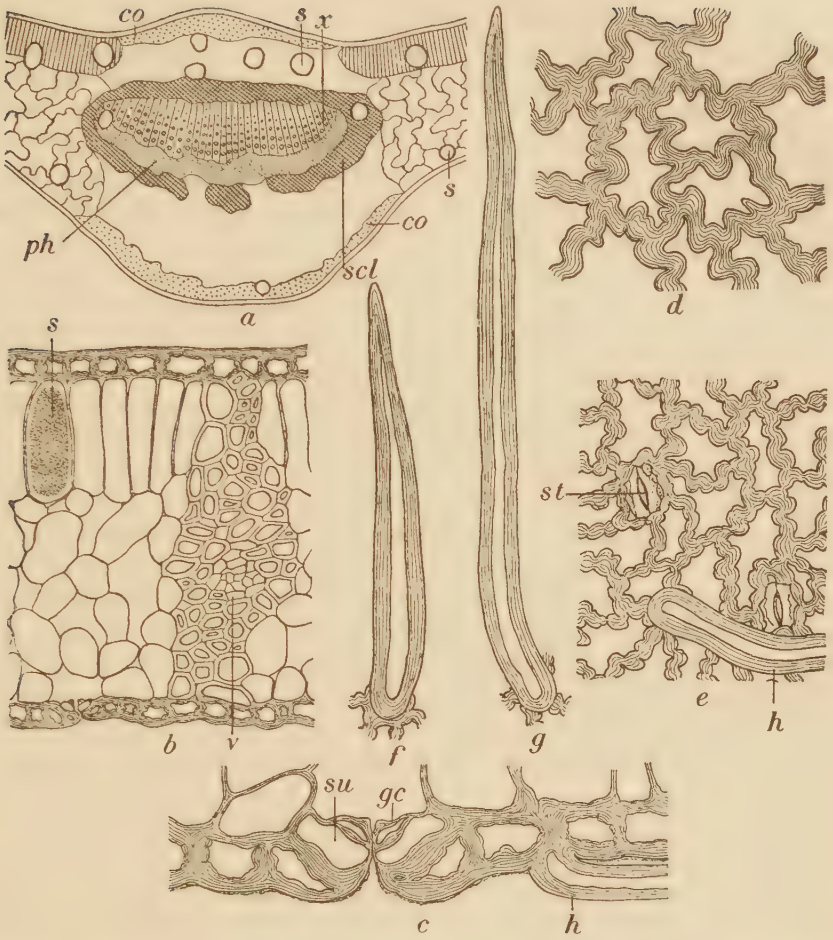

FIG. 10. *Cinnamomum iners; c*, a diagrammatic sketch of a transverse section of the midrib (*co*, collenchyma; *scl*, schlerenchyma; *ph*, phloëm; *x*, xylem; *s*, secretion cells); *b*, a segment of a transverse section of the blade (*v*, vein; *s*, secretion cell), × 250; *c*, a portion of a transverse section of the lower epidermis (*gc*, guard cells; *su*, subsidiary cells; *h*, hair), × 700; *d*, a portion of the surface view of the upper epidermis, × 540; *e*, a portion of the surface view of the lower epidermis (*st*, stomata; *h*, hair), × 540; *f* and *g*, simple hairs.

Microscopical structure.—The suberous coat in transverse section consists of ten to fourteen layers of tangentially elongated, closely fitted, and slightly suberized cork cells, all of which contain a reddish brown substance. Like the cork cells of cassia cinnamon, the outer layers have generally thin walls and the inner ones possess thick, pitted, and colorless walls, as represented on Plate 17, fig. 67. The phellogen is somewhat distinct.

The cortical parenchyma is composed of several layers of small polygonal and tangentially elongated cells, loaded with starch grains or a brownish substance and sometimes with calcium oxalate crystals (Plate 17, fig. 68). A few secretion cells that usually contain essential oil are scattered in this region. These secretion cells are similar to the ordinary parenchyma cells but are slightly larger and nearly rounded. The starch sheath is also inconspicuous.

The pericyclic region is similar to the pericyclic regions of *C. cassia* and *C. mercadoi,* but the stone cells are smaller and are arranged in comparatively smaller groups around the bark (Plate 17, fig. 68). The stone cells are separated by tangentially elongated parenchyma cells containing starch grains or some clinorhombic calcium oxalate crystals. The stone cells vary in shape and size. They are either rounded polygonal or tangentially elongated, and measure from 0.005 to 0.02 millimeter in diameter. Their walls are also pitted and slightly thickened at one side. Some of them contain starch grains and others a few calcium oxalate crystals. The inner part of the pericyclic is also composed of parenchyma cells, a few thick- or thin-walled stone cells, and some bast fibers (Plate 17, fig. 69). This region is traversed by medullary rays one or two cells wide. Between the parenchyma cells there are a few secretion cells which as in the other species of cinnamon contain either mucilage or essential oil.

The bast region occupies about one-half of the entire cross-section of the bark (Plate 17, fig. 70). It differs from those of the other species by (*a*) the numerous medullary rays, usually one cell wide; (*b*) the numerous bast fibers, isolated or in radial and tangential groups with distinct striation; and by (*c*) the small size of the secretion cells, which are very much fewer than the secretion cells of the other cinnamon species. The phloëm cells, as in the other barks, are all in a collapsed condition and their individual identity cannot be determined. The medullary-ray cells are loaded either with starch grains, calcium oxalate crystals, or a brownish substance. The bast fibers vary in outline from either rounded or quadrangular to rectangular with a very greatly reduced cavity. The secretion cells are found mostly empty and they measure from 0.036 to 0.045 millimeter in diameter. The medullary-ray cells are mostly one cell wide and radially elongated. Those towards the cambial region contain a brownish substance, and those towards the peripheral part

contain calcium crystals in clinorhombic forms. On Plate 17, fig. 72, a single medullary-ray cell filled with calcium oxalate crystals is represented. These crystals measure about 0.007 millimeter in length and about 0.002 millimeter in width.

The most characteristic part of the radial section is the middle part of the bast region. The bast fibers with tapering ends are found either singly or in groups of two or three cells. The secretion cells are axially elongated and found usually empty. The medullary ray consists of ten to twelve rows of cells, most of which contain calcium oxalate crystals and minute starch grains. A few stone cells are occasionally found mixed with the parenchyma cells in the outer part of the bast region. These cells, like those in the cross-section, exhibit slight one-sided thickening of their pitted walls. On Plate 17, fig. 71, a radial-section cut through near the outer part of the bast region is indicated.

The most conspicuous types of cells observed from the macerated preparation by Schultze's process are (*a*) the numerous bast fibers measuring from 0.1 to 0.2 millimeter in length and from 0.005 to 0.10 millimeter in diameter; (*b*) the very irregularly shaped stone cells with thick pitted cell walls and greatly reduced cavities (Plate 17, fig. 73, *a*), which measure from 0.015 to 0.06 millimeter in length and from 0.01 to 0.035 millimeter in width with slightly one-sided thickening (Plate 17, fig. 73, *b*); (*c*) the secretion cells, which are somewhat rounded or ovoid or elongated and measure from 0.02 to 0.05 millimeter in length and from 0.01 to 0.02 millimeter in diameter (Plate 17, fig. 73, *e*); (*d*) the cork cells, which are observed singly or in clusters, empty or filled with a brownish substance (Plate 17, fig. 73, *c*); (*e*) and the parenchyma cells with thickened, pitted, and slightly lignified cell walls (Plate 17, fig. 73, *d*).

CINNAMOMUM BURMANNI BLUME

This medium-sized tree is described in de Candolle's Prodromus(14) as follows:

Folíis oppositisque chartaceis e basi acutá ovalibus oblongis lanceolatisve attenuato-subacuminatis triplinervíis ramulisque glabris concoloribus v. subtus glaucinis, supranitidis levibus v. utrinque minute subprominolo-reticulatis, nervis lateralibus apicem versus evanescentibus v. cum intermedíi ramis confluentibus, paniculis simplicibus brevibus pubescentibus v. glabriusculis, ramis 3-4 floris, pedicellis florem aequantibus. In Chiná el Japoniá, introd.? in Java, Sumatrá, ins. Philipp. etc.

There are three important varieties under this species; namely, *Cinnamomum burmanni* Blm. var. *α chinense, C. burmanni* Blm. var. *β angustifolium,* and *C. burmanni* Blm. var. *γ kiamis.* The variety indicated by Meissner(14) supposed to be introduced in the Philippine Islands is *C. burmanni* Blm. var. *α chinense.* It is distinguished, according to him, by the shape and the size of the leaves, which are oblong-ovate to ovate and are from 3 to 6 inches long and from 1 to 2 inches wide, and by the fact that the lateral veins originate 1 to 2 lines above the base. The plant has an aromatic and slightly cinnamonlike odor. On Plate 18, fig. 74, a habit sketch of a portion of the branch, drawn from a herbarium specimen collected in Java, is represented.

Cinnamomum burmanni Blume is extensively cultivated in Sumatra and Java. According to Wijers(23) it grows in all soils, but does best in those that are deep, permeable, and rich in humus and at heights between 2,000 and 3,000 feet. In the Philippines this plant has never been reported in the living condition except the one indicated above seen by Merrill(16) at Nagcarlang, nor is there a single dried Philippine specimen in the Bureau of Science herbarium to prove its existence.

THE LEAVES

General external morphological characters.—The full-grown leaves of *Cinnamomum burmanni,* as far as the available foreign specimens in the Bureau of Science herbarium are concerned, show great similarity in size, shape, and texture to those of *C. mindanaense.* They measure from 7 to 15 centimeters in length by 2 to 5 centimeters at the widest part. They vary slightly in outline from oblong ovate, ovate, or ovate lanceolate to lanceolate; they are petiolate, trinerved, glabrous, chartaceous, shining above, and glaucous below (text fig. 11, *a–d*). The base is obtuse, occasionally inequilateral, and the apex is from acute to acuminate with an entire margin. The petioles are from 5 to 9 millimeters long, nearly cylindrical, and have a slight groove on the upper part. Two basal lateral veins arise about 7 millimeters above the base and extend to two-thirds the length of the blade. Numerous secondary veins, arising from the outer lateral part of the two basal primary veins, extend towards the margin and join each other. Towards the upper part of the midrib there are frequently a few veins more or less of the first degree which anastomose with each other.

Internal structure of the leaf.—The blade in the transverse section is bifacial and very similar to the transverse sections

of the blades of the other species, particularly to that of *C. mindanaense,* but it is thinner than the latter which is about 0.126 millimeter thick (text fig. 12, *b*). The upper epidermis, as well as the lower one, consists of single layers of rectangular, thick-walled, and highly cutinized cells, measuring about 0.012 millimeter and 0.01 millimeter in thickness, respectively. The palisade chlorenchyma is somewhat different from that of *C. mindanaense* because the cells are shorter, with a general tendency to form two layers. The lower one consists usually of short and more loosely arranged palisade cells. The upper palisade cells measure about 0.03 millimeter in length and 0.008 millimeter in width, while the lower palisade cells are about 0.015 millimeter in length and 0.006 millimeter in width.

FIG. 11. *Cinnamomum burmanni,* average leaves from foreign specimens; *a,* from material ex Herb. Hort. Bot. Bog.; *b* and *c,* from Preanger, Pangentjongan, Java; *d,* from Semarung, Oengaran, Java. × 0.5.

The spongy chlorenchyma occupies about two-thirds of the entire mesophyll and, as in the other species, is composed of small irregularly shaped cells with moderate-sized air spaces. The secretion cells are rounded and measure about 0.045 millimeter in diameter. They are usually found between the palisade cells, but sometimes in the spongy region. Those in the spongy region are smaller and measure only about 0.03 millimeter in diameter, as represented on text fig. 12, *b*. The stomata appear very similar to the stomata of the other species as shown on text fig. 12, *f*. Occasionally simple unicellular hairs are also observed in the lower surface. The transverse sections of the veins bear close resemblance to the vein structure of the other

species, especially to those of *C. mindanaense,* but they are not so well developed as those of the latter.

A transverse section cut through the midrib shows the same general characteristics as that of *C. mindanaense* (text fig. 12, *a*). The shape and the distribution of tissues are similar, but the midrib is usually very much thicker and wider. The collenchyma region is rarely fan-shaped and very few secretion cells are observed in the cortical parenchyma. The cortical parenchyma region is proportionately wider or larger than that of *C. mindanaense* or the other species. The vessels measure from 0.11 to 0.018 millimeter in diameter and are also arranged in radial rows.

Surface preparation.—The structure of the upper epidermis of *C. burmanni* is also quite similar to that of *C. mindanaense,* but in the former, the epidermal cells have slightly thinner and more undulated or sinuate walls (text fig. 12, *c*). They measure from 0.03 to 0.04 millimeter in their longest diameter and from 0.020 to 0.025 millimeter in their shortest diameter (text fig. 12, *c*). Their walls measure about 0.004 millimeter in thickness, and as in the other species are faintly striated. The lower epidermis is also very similar to the lower epidermis of *C. mindanaense,* but the stomata are less numerous and larger than those of the latter. The lower epidermal cells measure from 0.018 to 0.025 millimeter in their longest diameter and from 0.006 to 0.02 millimeter in their shortest diameter (text fig. 12, *d*). The simple unicellular hairs are not so numerous, and they are only found in the lower epidermis. They differ from the hairs of *C. mindanaense* in being usually shorter and in having thicker walls. They measure only about 0.09 millimeter in length (text fig. 12, *e*).

THE BARK

The barks arrived from Java in partially dried pieces. These pieces vary from 15 to 35 centimeters in length by from 1 to 5 centimeters in width and about 0.8 millimeter in thickness. They are either in simple quills, rolled up, or in flat pieces, as those indicated on Plate 19, fig. 76. The flattened pieces apparently were collected from the younger stem of the tree, for they are thinner and more pliable in texture. The external part is greenish brown or sepia, glistening with some more or less transverse grayish brown patches and with numerous small, nearly rounded lenticels. The inner surface is chocolate brown, smooth, and very finely striated. The older barks occur in quilled

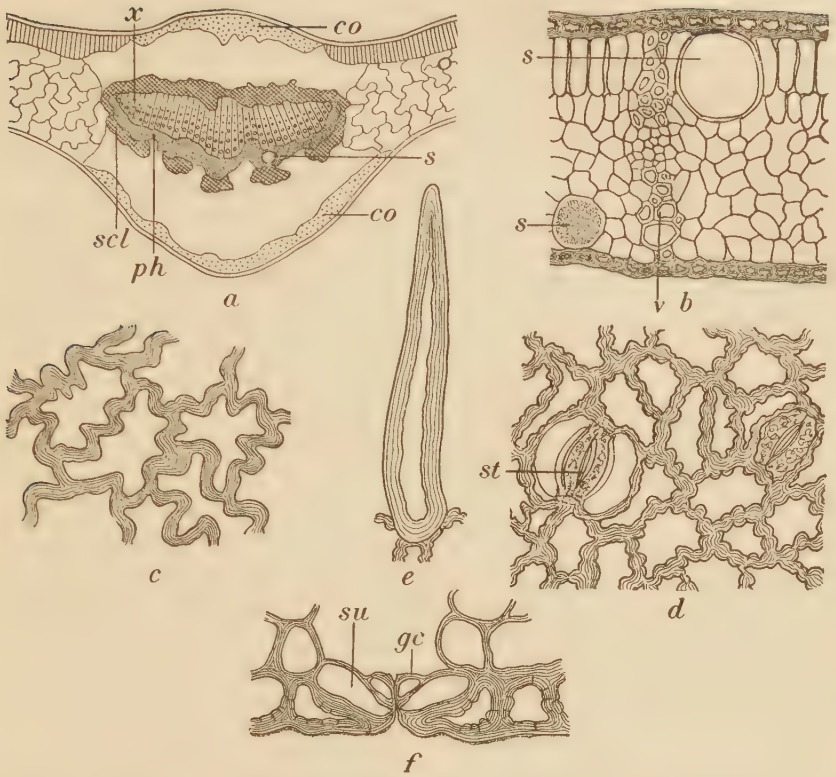

FIG. 12. *Cinnamomum burmanni; a,* a diagrammatic sketch of a transverse section of the midrib (*co,* collenchyma; *scl,* schlerenchyma; *ph,* phloëm; *x,* xylem; *s,* secretion cell); *b,* a segment of a transverse section of the blade (*v,* vein; *s,* secretion cells), × 250; *c,* a portion of the surface view of the upper epidermis, × 540; *d,* a portion of the surface view of the lower epidermis (*st,* stoma), × 540; *e,* a single hair; *f,* a portion of the transverse section of the lower epidermis (*gc,* guard cells; *su,* subsidiary cells), × 700.

pieces with the two sides rolled inward. The outer surface is grayish brown with sometimes yellowish white, axially elongated, narrow, scalelike strips of cuticle. These are produced by the shallow longitudinal fissures, which divide the cuticle into narrow and irregular, usually axially elongated, strips. The cuticle is somewhat rough with occasional transversely elongated leaf or branch scars. The middle part is finely granular and slightly fibrous. The inner surface is light brown and smooth with very fine longitudinal striation. The fracture is short, uneven, and fibrous. The odor is aromatic like that of cassia bark, and the taste is slightly astringent and sweetish.

Microscopical structure.—A transverse section of the bark is quite similar to that of *Cinnamomum mindanaense* except that the liber of *C. burmanni* contains numerous bast fibers and

fewer mucilage cells (Plate 20, fig. 79). The periderm consists of three to four layers of tangentially elongated cells. The cortical part is composed of ten to fourteen layers of tangentially elongated thin-walled parenchyma cells, most of which contain minute starch grains (Plate 20, figs. 77 and 78). Intermingled with the parenchyma cells, there are numerous secretion cells that contain mostly a yellowish essential oil. They are slightly tangentially elongated and vary in size from 0.04 to 0.08 millimeter in their longest diameter and from 0.025 to 0.04 millimeter in their shortest diameter. The innermost part of the cortex is limited by the starch sheath. The middle region is similar to that of *C. mindanaense* although the material is much younger. The stone-cell ring is very much interrupted in various places with parenchyma cells. The stone cells are either polygonal in outline or tangentially elongated (Plate 20, fig. 78). They have thinner walls than the stone cells of the same region of *C. mindanaense,* but like the stone cells of the latter, one side of their walls is slightly thicker than the other and they usually contain minute starch grains or, sometimes, calcium oxalate crystals in prismatic form. The inner part of the pericyclic region is also composed of several layers of parenchyma cells containing either starch grains or calcium oxalate crystals. Scattered along this region there are some secretion cells, some of which contain mucilage with distinct striation and some contain a yellowish essential oil.

The phloëm or bast region is rather thick, occupying about one-half of the total thickness of the section (Plate 20, fig. 79). The sieve tubes and companion cells are not prominent, some of them can only be recognized either by their undulated walls or by their nearly collapsed condition, like those of the other species described above. The phloëm parenchyma cells are tangentially elongated and those towards the periphery contain starch grains or sometimes calcium oxalate crystals in prismatic form, while those towards the cambial region are mostly empty. Scattered between the phloëm parenchyma cells, there are some small bast fibers, isolated or in groups of two cells. The secretion cells are not so numerous, and they are comparatively smaller than the secretion cells observed in the same region of the transverse section of the bark of *C. mindanaense.* The bast region is traversed by medullary rays two to four cells wide. The medullary-ray cells are radially elongated and mostly filled up with prismatic calcium oxalate crystals or starch grains

or, sometimes, with both calcium oxalate crystals and minute starch grains like those of *C. mindanaense* (Plate 20, figs. 81 and 82).

The radial section cut through the phloëm region is characterized by the much-elongated secretion cells measuring about 0.16 millimeter in length, the few spindle-shaped bast fibers, and by medullary rays eight to ten cells wide. The sieve tubes are sometimes conspicuous. They are identified by their lengths, the characteristic sieve plates, and their denser content. On Plate 20, fig. 80, a portion of the radial section cut through the bast region is indicated.

The most conspicuous elements observed in the preparations from the material macerated by Schultze's maceration process may be described as follows: (*a*) The thin and slender spindle-shaped bast fibers of from 0.08 to 0.46 millimeter in length (Plate 21, fig. 83, *a*). Their tips are sometimes sharply pointed, and their sides more or less undulated in outline. (*b*) The stone cells, as the ones found in the transverse section, are comparatively smaller than those of *C. mindanaense* or than those of the other species and they have thinner walls (Plate 21, fig. 83, *b* and *e*). They are from 0.012 to 0.04 millimeter long, and from 0.008 to 0.02 millimeter wide, with one side of their walls slightly thinner than the other. (*c*) The secretion cells are isolated or in axial groups of two or, sometimes are embedded with the phloëm parenchyma cells (Plate 21, fig. 83, *c*). They are easily identified because they usually contain droplets of a substance stainable by alkanna tincture or osmic acid solution. They vary in shape from nearly round to elongate and from 0.02 to 0.05 millimeter in length and 0.012 to 0.016 millimeter in width. (*a*) The small medullary rays in tangential view are occasionally observed surrounded by a few parenchyma cells (Plate 21, fig. 83, *d*).

SUMMARY AND CONCLUSION

1. The leaves of the above species of cinnamon trees externally exhibit great variations in various features; namely, shape, size, thickness, texture, etc. The most variable among them are *Cinnamomum zeylanicum* Blm., *C. iners* Reinw., and *C. mercadoi* Vid.; the rest and the less-variable ones are *C. cassia* Blm., *C. mindanaense* Elm., and *C. burmanni* Blm. As a whole, *C. zeylanicum* has the thickest but least-glabrous leaves with the lateral veins extending very close to the tip; whereas *C. iners*

possesses the largest average leaves, which are thinner and more glabrous than those of *C. zeylanicum,* and their lateral veins usually extend clear to the apex. *Cinnamomum mercadoi,* on the other hand, has from large to very small average leaves; the leaves of the high-altitude forms, especially, are very small. The leaves are more shiny above and glabrous below with somewhat distinct reticulate venations.

2. The leaves of *C. mindanaense* and of *C. burmanni* are very similar, but the former are usually slightly thicker than the latter and the principal lateral veins in the leaves of *C. mindanaense* usually extend about three-fourths the length of the blade, whereas in those of *C. burmanni* they extend two-thirds the length of the blade. The leaves of *C. cassia* are the thinnest and their principal lateral veins extend very close to the apex.

3. Although the cinnamon leaves exhibit much variation in their various external features yet they show great resemblance in their anatomical structure. Their epidermal cells are quite the same in characteristics except in some specimens of *C. mercadoi,* where they are papillous.

4. They all possess single layers of palisade chlorenchyma with a tendency to produce secondary narrow palisade layers as observed in *C. mercadoi* and *C. burmanni.*

5. The secretion cells of the leaves containing yellowish essential oil or, sometimes, mucilage occur in the mesophyll as well as in the midrib in all the species.

6. Simple unicellular hairs are found on the lower surface of the leaves in all the species. In *C. zeylanicum* and *C. burmanni* they are usually short, thick-walled, and scanty, while in *C. cassia* and *C. mindanaense* they are either short, or long with thinner walls, and are more numerous than those of the former; in *C. mercadoi* and *C. iners* they are usually very long with thick walls and very abundant.

7. The epidermal cells of all the species in the surface view are polygonal in outline with sinuate thick walls. The walls of the epidermal cells vary in thickness according to the species of cinnamon. The stomata are abundant and confined to the lower surface only. The guard cells are depressed and bordered and overarched by subsidiary cells.

8. The transverse sections of the midrib of *C. zeylanicum* and *C. mercadoi* are quite similar; both are somewhat flattened with fan-shaped collenchyma regions in the upper part, while the cross-sections of the midribs of *C. iners, C. mindanaense, C. bur-*

manni, and *C. cassia* are all slightly convex above and strongly convex below. *Cinnamomum iners* is distinguished from the others by the presence of very numerous secretion cells in the cortical region of the midrib, while *C. cassia* is characterized by the extension of the palisade regions to the upper part of the midrib.

9. The barks with a complete periderm of the six species and of about the same age appear very much alike, but without the suberous coat *C. zeylanicum* exhibits finer grains and smoother surfaces with longitudinal striations.

10. The structure of the barks of the six species exhibits a great resemblance. The barks of *C. zeylanicum, C. mindanaense,* and *C. burmanni* have a finer structure than those of the other three. They are all characterized by the presence of the secretion cells containing yellowish essential oil or mucilage, the remarkable stone cells in the pericyclic region with one-sided thickening, the bast fibers, the calcium oxalate crystals, and the medullary rays.

11. The secretion cells in the bark are found in the cortex, in the inner part of the pericyclic region, and especially in the bast. In *C. burmanni, C. zeylanicum,* and *C. iners* the secretion cells are numerous in the cortex. The secretion cells containing mucilage are very abundant in the bast of *C. mindanaense.*

12. The stone cells form, more or less, a complete ring in *C. zeylanicum;* are somewhat continuous in *C. mindanaense* and *C. burmanni;* but are much interrupted in *C. cassia, C. mercadoi,* and *C. iners.* They are very large with thick walls in *C. zeylanicum* and *C. mercadoi,* but thinner with a distinct one-side thickening in *C. cassia, C. mindanaense, C. burmanni,* and *C. iners.* In *C. cassia, C. iners,* and *C. burmanni* they usually contain starch grains, sometimes mixed with calcium oxalate crystals.

13. The bast fibers are found in all the phloëm regions of the above species, except *C. mindanaense,* in which they are either absent or very scanty. The bast fibers are few and small in *C. mindanaense* and *C. burmanni,* but they are large and numerous in *C. cassia, C. mercadoi,* and *C. iners.* The longest and smallest bast fibers are observed in *C. burmanni.*

14. The calcium oxalate crystals are observed in the medullary-ray cells, phloëm parenchyma, pericyclic, and cortical parenchymas, and frequently are mixed with starch grains. In *C. cassia* and *C. mercadoi* they are small and in raphide forms, whereas in *C. zeylanicum* they are either in clinorhombic or

prismatic forms and in *C. iners* are all clinorhombic or fusiform. In *C. mindanaense* and *C. burmanni*, on the other hand, they are large and in prismatic or sometimes cubical forms.

15. The medullary rays usually are from one to two cells wide in *C. zeylanicum, C. cassia, C. mercadoi,* and *C. iners;* whereas in *C. mindanaense* and *C. burmanni* they are from one to four or more cells wide. The medullary ray cells contain either brown substance, calcium oxalate crystals, or starch grains, or both calcium oxalate crystals and starch grains.

16. The above six species, therefore, can be distinguished one from another as follows:

(*a*) *Cinnamomum zeylanicum* by its large thick leaves, the two lateral veins extended close to the apex, the secretion cells usually in the palisade region, the striation in the outer part of its bark without suberous coat, the continuous stone-cell ring, and the calcium oxalate crystals in clinorhombic and prismatic forms.

(*b*) *Cinnamomum cassia* is characterized by its moderate size and very thin leaves, the palisade region usually extended over the upper part of the midrib, the secretion cells in the palisade and spongy regions, and by the coarse structure of its barks with the stone-cell ring much interrupted and calcium oxalate crystals in raphides.

(*c*) *Cinnamomum mindanaense* by the usually small and thin leaves with the lateral veins usually extended to three-fourths of the length of the leaf, the large hairs with thin walls, the fine structure of its bark with 2- to 3-cell-wide medullary ray, the bast fibers being usually wanting, the calcium oxalate crystals in prismatic form, and the numerous mucilage secretion cells in the liber.

(*d*) *Cinnamomum mercadoi* is identified by its variable size of leaves from very small to large, thick and shining above; the secretion cells usually in the second layer of palisade and spongy regions and the lower epidermal cells sometimes papillous with very thick walls and numerous simple hairs; the coarse structure of its bark with secretion cells in the medullary rays; and the crystals in clinorhombic and raphide forms.

(*e*) In *Cinnamomum iners*, on the other hand, the leaves are large and thin, glabrous below, with lateral veins usually extending to the apex, and the secretion cells are in the palisade region. Its bark is somewhat coarse in structure, the stone cells are small and in an interrupted ring; the secretion cells are small, and crystals of oxalate of calcium are in minute clinorhombic forms.

(*f*) *Cinnamomum burmanni* is recognized by its small, thin leaves, the lateral veins extending usually to two-thirds of the length of the leaves, and the secretion cells in palisade and spongy regions; and by its very long thin bast fibers, the small number of secretion mucilage cells, the medullary rays usually from three to four cells wide, and the calcium oxalate crystals in prismatic form.

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ILLUSTRATIONS

[All drawings by the author except Plate 2, fig. 8, which was made by Macario Ligaya, of the Bureau of Science. The photographs were prepared by the photographer, Bureau of Science].

Plate 1. Cinnamomum zeylanicum Blume

Fig. 1. A habit sketch of a portion of a young branch with flowers. × 0.5.
2. A single flower. × 5.
3. An inner stamen, enlarged.
4. An outer stamen, enlarged.
5. A staminode, enlarged.
6. A longitudinal floral diagram.

Plate 2. Cinnamomum zeylanicum Blume

Fig. 7. Photograph of the barks deprived of the suberous coat as sold in the market.
8. A detailed drawing of a portion of the stick of bark made of the overlapping thin and quilled barks without suberous coats. × 0.75.

Plate 3. Cinnamomum zeylanicum Blume

Fig. 9. A portion of the transverse section of the periderm and cortex; *k*, cork; *s*, secretion cell. × 165.
10. A segment of a transverse section of the pericycle of a young bark; *pf*, primary bast fibers. × 165.
11. A segment of a transverse section of a bark without suberous coat; *sc*, stone cells of the pericycle; *sm*, secretion cell containing mucilage; *m*, medullary rays; *ph*, phloëm; *bf*, bast fibers; *ca*, calcium oxalate crystals. × 165.
12. A portion of the radial section; *m*, medullary ray; *ca*, calcium oxalate crystals; *s*, secretion cell; *bf*, bast fiber; *st*, sieve tubes; *sc*, stone cells; *sg*, starch grains. × 165.
13. Two medullary-ray cells containing prismatic and clinorhombic calcium oxalate crystals, *ca*, and starch grains, *sg*. × 700.
14. A secretion cell from the cortical parenchyma containing essential oil and surrounded by parenchyma cells which contain a few starch grains. × 250.
15. A secretion cell from the inner part of the pericyclic region containing mucilage and surrounded by parenchyma cells which contain a few starch grains. × 250.
16. A small portion of a radial section of the pericyclic region showing radially elongated stone cells. × 165.

FIG. 17. Another very small segment of the radial section of the pericyclic region; *sc*, stone cell. × 165.

PLATE 4. CINNAMOMUM ZEYLANICUM BLUME

FIG. 18. Different elements drawn from the powder; *a*, a fragment with a bast fiber and tangential view of a medullary ray; *b*, a group of parenchyma cells with thick and pitted cell walls; *c*, cork cells; *d*, a group of schlerenchyma cells and bast fibers; *e*, parenchyma cells with starch grains; *f*, fragments from the phloëm region; *g*, secretion cells; *h*, stone cells. × 450.

19. Some of the most important cells found in the macerated preparation; *a*, secretion cells; *b* and *c*, groups of stone cells arranged in rows. × 450.

PLATE 5. CINNAMOMUM CASSIA BLUME

FIG. 20. Photograph of dried bark with suberous coat as sold in the market.

PLATE 6. CINNAMOMUM CASSIA BLUME

FIG. 21. A portion of the transverse section through the periderm and cortex; *k*, cork region; *ca*, calcium oxalate crystals. × 165.

22. A portion of the transverse section of the pericycle; *sc*, stone cells; *sg*, starch grains. × 165.

23. A portion of the transverse section of the bast region; *bf*, bast fiber; *ph*, phloëm cells; *s*, secretion cell. × 165.

24. A medullary-ray cell containing calcium oxalate crystal in raphide, *ca*, and starch grains, *sg*. × 700.

25. A small portion of a transverse section of the medullary ray; *s*, secretion cell; *bf*, bast fiber; *sc*, stone cells. × 700.

PLATE 7. CINNAMOMUM CASSIA BLUME

FIG. 26. A parenchyma cell with thick, slightly lignified, pitted walls and containing calcium oxalate crystals, *ca*, mixed with the starch grains, *sg*. × 700.

27. Different types of cells drawn from the macerated material; *a*, a fragment of tissue consisting of *bf*, bast fiber; *m*, tangential view of a medullary ray surrounded by parenchyma cells; *b*, another fragment with a small medullary ray, *m*, and parenchyma cells; *c*, a group of bast fibers one of which has a small medullary ray, *m*, attached at one side; *d*, cork cells; *e*, a group of stone cells; *f*, secretion cells. × 450.

PLATE 8. CINNAMOMUM MINDANAENSE ELMER

FIG. 28. A habit sketch of a portion of a young branch with flowers. × 0.5.

29. A single large leaf. × 0.5.

30. *a*, A single flower, × 5; *b*, an inner stamen, enlarged; *c*, a staminode, enlarged; *d*, an outer stamen, enlarged.

31. A floral diagram.

32. A pistil, enlarged.

33. A cluster of mature fruits. × 0.5.

PLATE 9. CINNAMOMUM MINDANAENSE ELMER

FIG. 34. Photograph of the bark, *a–c*, without suberous coat, the last of which is about 1 meter long; *f*, photograph of the bark with suberous coat.

PLATE 10. CINNAMOMUM MINDANAENSE ELMER

FIG. 35. A segment of a transverse section of the pericyclic region; *sc*, stone cells; *s*, secretion cell; *m*, medullary ray. × 165.

36. A segment of a transverse section of the inner part of the pericyclic region; *sm*, mucilage-secretion cell; *s*, oil-secretion cell; *m*, medullary ray; *pf*, primary bast fibers. × 165.

37. A portion of the inner part of a transverse section of the phloëm region; *ph*, phloëm; *m*, medullary ray; *s*, secretion cell; *ca*, calcium oxalate crystals. × 165.

38. A portion of the radial section through the cortex and pericycle; *sm*, mucilage-secretion cell; *s*, secretion cell; *sc*, stone cell; *ca*, calcium oxalate crystals; *sg*, starch grains. × 165.

39. A small segment of the transverse section of a medullary ray indicating, *ca*, calcium oxalate crystals. × 700.

PLATE 11. CINNAMOMUM MINDANAENSE ELMER

FIG. 40. A portion of the radial section through the sclerenchyma region in the inner part of the pericyclic region, showing some of the primary bast fibers, *pbf*, and stone cells, *sc*. × 165.

41. A portion of the radial section through the phloëm region; *m*, medullary ray; *s*, secretion cell; *ca*, calcium oxalate crystals. × 165.

42. Different types of cells from the powder and macerated material; *a*, fragments from the phloëm region showing, *m*, transverse view of a medullary ray; *b*, groups of stone cells; *c*, groups of bast fibers; *d*, fragments from the parenchyma region, some of which have thick and pitted walls and contain starch grains; *e*, groups of starch grains; *f*, cork cells; *g*, calcium oxalate crystals; *h*, secretion cells from the powder and macerated material. × 450.

PLATE 12. CINNAMOMUM MERCADOI VIDAL

FIG. 43. A habit sketch of a portion of a young branch with flowers. × ½.

44. A single large leaf. × ½.

45. A single flower. × ½.

46. A longitudinal floral diagram.

47. A segment of the perianth with a single outer stamen, enlarged.

48. An inner stamen, enlarged.

49. A staminode, enlarged.

50. A pistil, enlarged.

51. Two mature fruits. × ½.

PLATE 13. CINNAMOMUM MERCADOI VIDAL

FIG. 52. Photograph of dried bark with periderm; *a*, an older bark from the trunk; *b*, dorsal view of a younger bark; *c*, ventral view of the other half of the same bark.

PLATE 14. CINNAMOMUM MERCADOI VIDAL

FIG. 53. A small segment of the transverse section through the cork region; *k*, cork; *sc*, stone cell. × 165.

54. A segment from the transverse section of the pericyclic region; *sc*, stone cell; *sg*, starch grains. × 165.

55. A segment from a transverse section of the inner part of the pericyclic region; *s*, secretion cell; *sg*, starch grains; *sc*, stone cell. × 165.

56. A segment from a transverse section of the outer part of the bast region; *bf*, bast fibers; *s*, secretion cell; *ca*, calcium oxalate crystals; *m*, medullary ray. × 165.

57. A segment from a transverse section of the phloëm region of a fresh specimen; *bf*, bast fibers; *m*, medullary ray; *ca*, calcium oxalate crystals; *s*, secretion cells; *ph*, phloëm cells. × 165.

58. Another segment from a transverse section of the phloëm region, but from dried material; *s*, secretion cell; *m*, medullary ray; *bf*, bast fibers; *ph*, phloëm. × 165.

59. A portion of a radial section through the phloëm region; *bf*, bast fibers; *ca*, calcium oxalate crystals; *ph*, phloëm cells; *s*, secretion cells; *m*, medullary ray. × 165.

PLATE 15. CINNAMOMUM MERCADOI VIDAL

FIG. 60. A parenchyma cell containing calcium oxalate crystals in raphides, *ca*. × 700.

61. Different types of cells drawn from the macerated material; *a*, a group of bast fibers; *b*, groups of stone cells; *c*, two mucilage-secretion cells; *d*, groups of cork cells; *e*, parenchyma cells with thick and pitted walls, × 450; *f*, starch grains, × 700; *g*, a group of secretion cells, × 450.

PLATE 16. CINNAMOMUM INERS REINWARDT

FIG. 62. A habit sketch of a portion of a young branch with flowers. × 0.4.

63. A single flower. × 4.

64. A diagrammatic sketch of a dissected perianth showing the relative position of the stamens, enlarged.

65. *a*, An inner stamen; *b*, an outer stamen; *c*, a staminode, enlarged.

66. A single fruit. × 1.

PLATE 17. CINNAMOMUM INERS REINWARDT

FIG. 67. A segment from a transverse section of the periderm; *k*, cork; *sc*, stone cell; *p*, phellogen layer. × 165.

FIG. 68. A segment from a transverse section through the cortex and pericycle; *s*, secretion cell containing essential oil; *cp*, cortical parenchyma; *ca*, calcium oxalate crystals; *sc*, stone cells of the pericyclic region. × 165.

69. A segment from a transverse section of the outer part of the phloëm region; *m*, medullary ray; *bf*, bast fibers; *ca* calcium oxalate crystals; *sg*, starch grains. × 165.

70. A segment from the transverse section of the innermost part of the phloëm region; *m*, medullary ray; *bf*, bast fibers; *s*, secretion cell; *ph*, phloëm. × 165.

71. A portion of the radial section of the phloëm region; *m*, medullary ray; *bf*, bast fibers; *s*, secretion cell; *ca*, calcium oxalate crystals; *st*, sieve tube. × 165.

72. A medullary-ray cell from a radial section containing calcium oxalate crystals, *ca*. × 700.

73. Groups of elements from the macerated material; *a*, a group of bast fibers; *b*, stone cells; *c*, cork cells; *d*, parenchyma cells with thick and pitted walls; *e*, secretion cells containing either essential oil or mucilage. × 450.

PLATE 18. CINNAMOMUM BURMANNI BLUME

FIG. 74. A portion of a young branch with flowers drawn from dried material from Java; *a*, a single large leaf. × 2/3.

PLATE 19. CINNAMOMUM INERS REINWARDT AND CINNAMOMUM BURMANNI BLUME

FIG. 75. *Cinnamomum iners; a*, photograph of a dorsal view of a piece of dried bark, collected by C. F. Baker in Mindanao; *b*, ventral view of the same piece of bark.

76. *Cinnamomum burmanni*, photograph of the dried bark, specimen from Buitenzorg botanical garden; *a*, from an older stem; *b*, from a younger stem.

PLATE 20. CINNAMOMUM BURMANNI BLUME

FIG. 77. A portion of a transverse section through the cortical and pericyclic region of a younger bark; *sc*, stone cells. × 165.

78. A section similar to the one illustrated in fig. 77, but from an older bark; *s*, secretion cell; *ca*, calcium oxalate crystals; *sc*, stone cells of the pericycle. × 165.

79. A segment from a transverse section of the inner part of the bast region; *m*, medullary ray; *bf*, bast fibers; *ca*, calcium oxalate crystals; *s*, secretion cells; *sm*, secretion cell with mucilage; *ph*, phloëm. × 165.

80. A portion of the radial section drawn from the middle part of the phloëm region; *bf*, bast fiber; *st*, sieve tube; *s*, secretion cell; *m*, medullary ray. × 165.

81. A few medullary-ray cells from a transverse section; *ca*, calcium oxalate crystals; *sg*, starch grains. × 700.

82. Another medullary-ray cell in radial section; *ca*, calcium oxalate crystals; *sg*, starch grains. × 700.

PLATE 21. CINNAMOMUM BURMANNI BLUME

FIG. 83. Different isolated elements drawn from the macerated material; *a*, a group of bast fibers; *b*, stone cells; *c*, stone cells with thinner walls, the smaller ones of which are from the cork region and the larger cells from the parenchyma region; *d*, medullary ray in tangential view with some parenchyma cells; *e*, secretion cell. × 450.

TEXT FIGURES

FIG. 1. *Cinnamomum zeylanicum*, average leaves from different specimens from the Philippines and abroad; *a*, from the garden of the University of the Philippines; *b* and *g*, from Tabogo, West Indies; *c*, from Tondo, Manila; *d*, from Bataan, Luzon; *e*, from Java. × 1/3.

2. *Cinnamomum zeylanicum; a*, diagrammatic representation of a transverse section of the midrib (*co*, collenchyma; *scl*, sclerenchyma; *ph*, phloëm; *x*, xylem; *s*, secretion cells); *b*, a segment of a transverse section of the blade (*s*, secretion cells; *v*, vein), × 250; *c*, a portion of the surface view of the upper epidermis, × 540; *d*, a portion of the surface view of the lower epidermis (*st*, stomata), × 540; *e*, a single hair, × 540; *f*, a portion of a transverse section of the lower epidermis showing a stoma from a specimen from Java (*gc*, guard cells; *sc*, subsidiary cells), × 700; *g*, a segment from a transverse section of the lower epidermis of a fresh leaf, × 700.

3. *Cinnamomum cassia; a*, *b*, and *c*, three average leaves from the three Chinese specimens in the herbarium, × 0.5; *d*, a diagrammatic representation of a transverse section of the midrib (*co*, collenchyma; *scl*, sclerenchyma; *ph*, phloëm; *x*, xylem; *s*, secretion cells; *ha*, simple hair); *e*, a segment of the transverse section of the blade (*v*, vein; *s*, secretion cell), × 250; *f*, portion of the surface view of the upper epidermis, × 540; *g*, portion of the surface view of the lower epidermis (*st*, stoma), × 540; *h*, a portion of a transverse section of the lower epidermis showing a stoma (*gc*, guard cells; *su*, subsidiary cells), × 700; *i* and *j*, two simple hairs, × 540.

4. *Cinnamomum mindanaense*, average leaves from the different specimens; *a*, a leaf from the specimen from Zamboanga; *b*, from Surigao; *c*, from Misamis; *d*, from a cotype specimen from Mount Apo, Todaya, Davao. × 0.5.

5. *Cinnamomum mindanaense; a*, a diagrammatic sketch of a transverse section of the midrib (*co*, collenchyma; *scl*, sclerenchyma; *ph*, phloëm; *x*, xylem; *s*, secretion cell); *b*, a segment of a transverse section of the blade (*v*, vein; *s*, secretion cell), × 250; *c*, a portion of a transverse section of the lower epidermis showing a stoma (*gc*, guard cells; *sc*, subsidiary cells), × 700; *d*, a segment of the surface view of the upper epidermis, × 540; *e*, a segment of the surface view of the lower epidermis (*st*, stomata), × 540; *f*, a single hair, × 540.

FIG. 6. *Cinnamomum mercadoi*, average leaves from specimens from various parts of Luzon; *a* and *d*, from Rizal; *b*, from Laguna; *c*, from Isabela; *e*, from Bontoc; *f*, from Benguet; *g*, from Mount Umingan; *h*, from Mount Bulilao, Capiz. × 0.5.

7. *Cinnamomum mercadoi; a*, a diagrammatic sketch of a transverse section of the midrib (*co*, collenchyma; *scl*, schlerenchyma; *ph*, phloëm; *x*, xylem; *s*, secretion cell); *b*, a segment of a transverse section of the blade from a cotype specimen, *2459*, (*v*, vein; *s*, secretion cell), × 250; *c*, a segment of a transverse section of the blade of specimen *4678*, showing papillous type of lower epidermal cell (*h*, hair), × 250; *d*, a segment of a transverse section of the blade from specimen *20933*, × 250; *e*, a portion of a transverse section of the lower epidermis showing a stoma (*gc*, guard cell; *su*, subsidiary cells), × 700; *f*, a portion of a transverse section of the lower epidermis of specimen *46783*, showing also a stoma (*gc*, guard cells; *su*, subsidiary cells), × 700.

8. *Cinnamomum mercadoi; a*, a portion of a surface view of the upper epidermis, × 540; *c*, a portion of a surface view of the lower epidermis (*st*, stoma), × 540; *c* and *d*, portion of the surface view of the lower epidermis of specimen *46783* (*p*, papilla), × 540; *e* and *f*, simple hairs, × 540.

9. *Cinnamomum iners*, average leaves from specimens from the Philippines and from abroad; *a*, from Java; *b*, from Camp Kithley, Lake Lanao, Mindanao; *c*, from Eil Simaloer bij., Sumatra; *d*, from Res. Palembang, Sumatra; *e* and *h*, from Catubig River, Samar; *g*, from herb. L. Pierre *6170*. × 1/3.

10. *Cinnamomum iners; a*, a diagrammatic sketch of a transverse section of the midrib (*co*, collenchyma; *scl*, schlerenchyma; *ph*, phloëm; *x*, xylem; *s*, secretion cells); *b*, a segment of a transverse section of the blade (*v*, vein; *s*, secretion cell), × 250; *c*, a portion of a transverse section of the lower epidermis (*gc*, guard cells; *su*, subsidiary cells; *h*, hair), × 700; *d*, a portion of the surface view of the upper epidermis, × 540; *e*, a portion of the surface view of the lower epidermis (*st*, stomata; *h*, hair), × 540; *f* and *g*, simple hairs.

11. *Cinnamomum burmanni*, average leaves from foreign specimens; *a*, from material ex Herb. Hort. Bot. Bog.; *b* and *c*, from Preanger, Pangentjongan, Java; *d*, from Semarung, Oengaran, Java. × 0.5.

12. *Cinnamomum burmanni; a*, a diagrammatic sketch of a transverse section of the midrib (*co*, collenchyma; *scl*, schlerenchyma; *ph*, phloëm; *x*, xylem; *s*, secretion cell); *b*, a segment of a transverse section of the blade (*v*, vein; *s*, secretion cells), × 250; *c*, a portion of the surface view of the upper epidermis, × 540; *d*, a portion of the surface view of the lower epidermis (*st*, stoma), × 540; *e*, a single hair; *f*, a portion of the transverse section of the lower epidermis (*gc*, guard cells; *su*, subsidiary cells), × 700.

PLATE 1. CINNAMOMUM ZEYLANICUM BLUME.

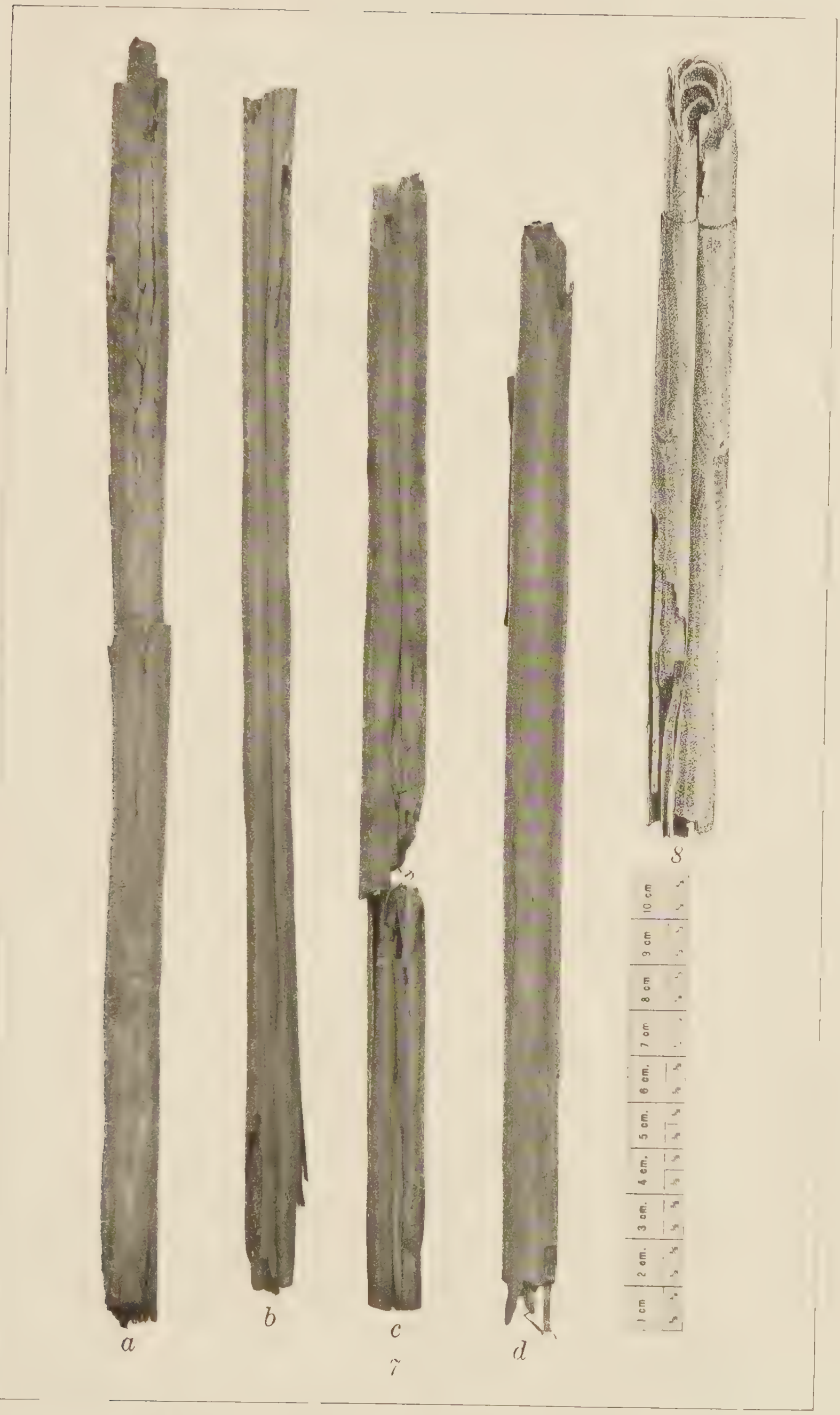

PLATE 2. CINNAMOMUM ZEYLANICUM BLUME.

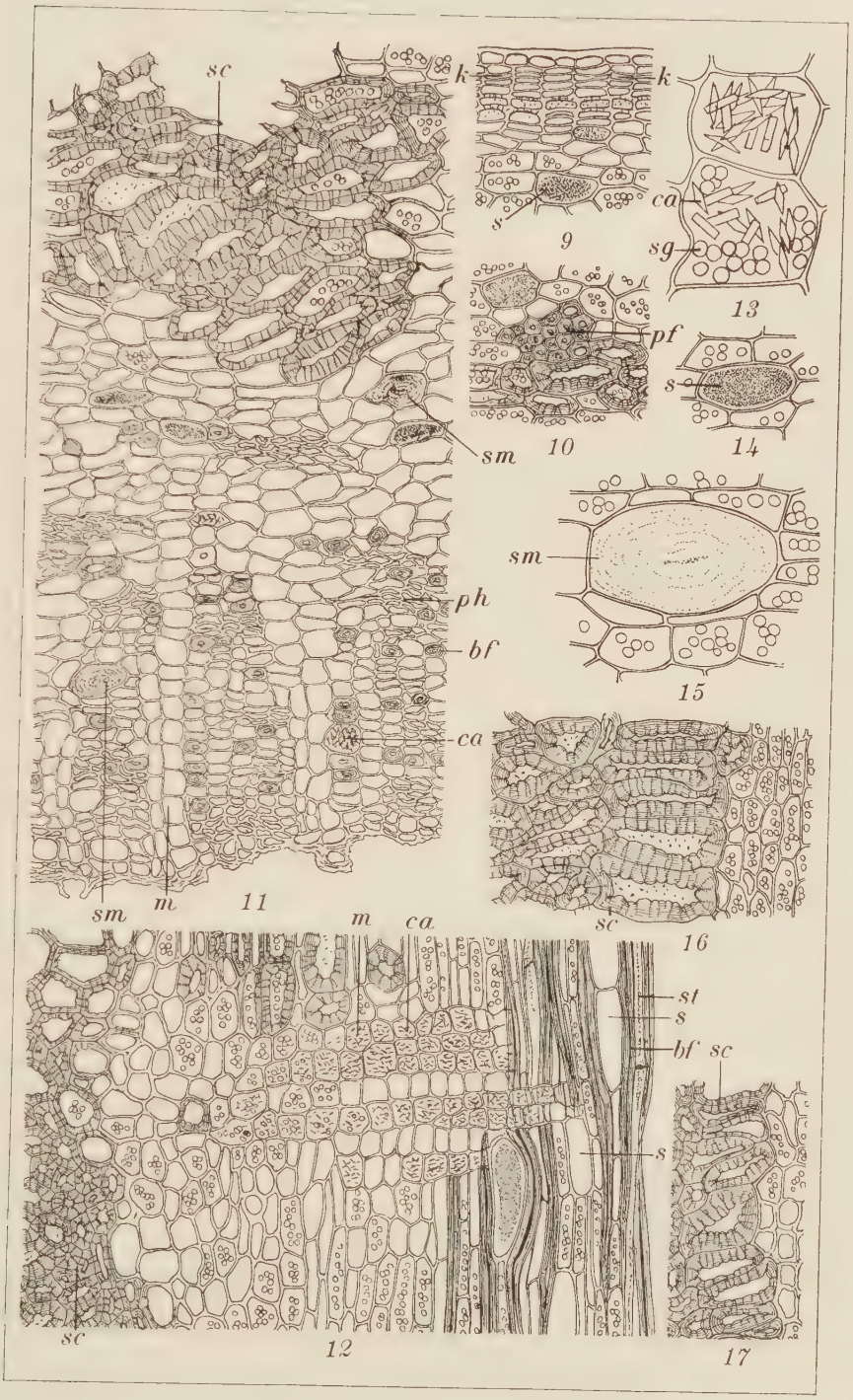

PLATE 3. CINNAMOMUM ZEYLANICUM BLUME.

PLATE 4. CINNAMOMUM ZEYLANICUM BLUME.

PLATE 5. CINNAMOMUM CASSIA BLUME.

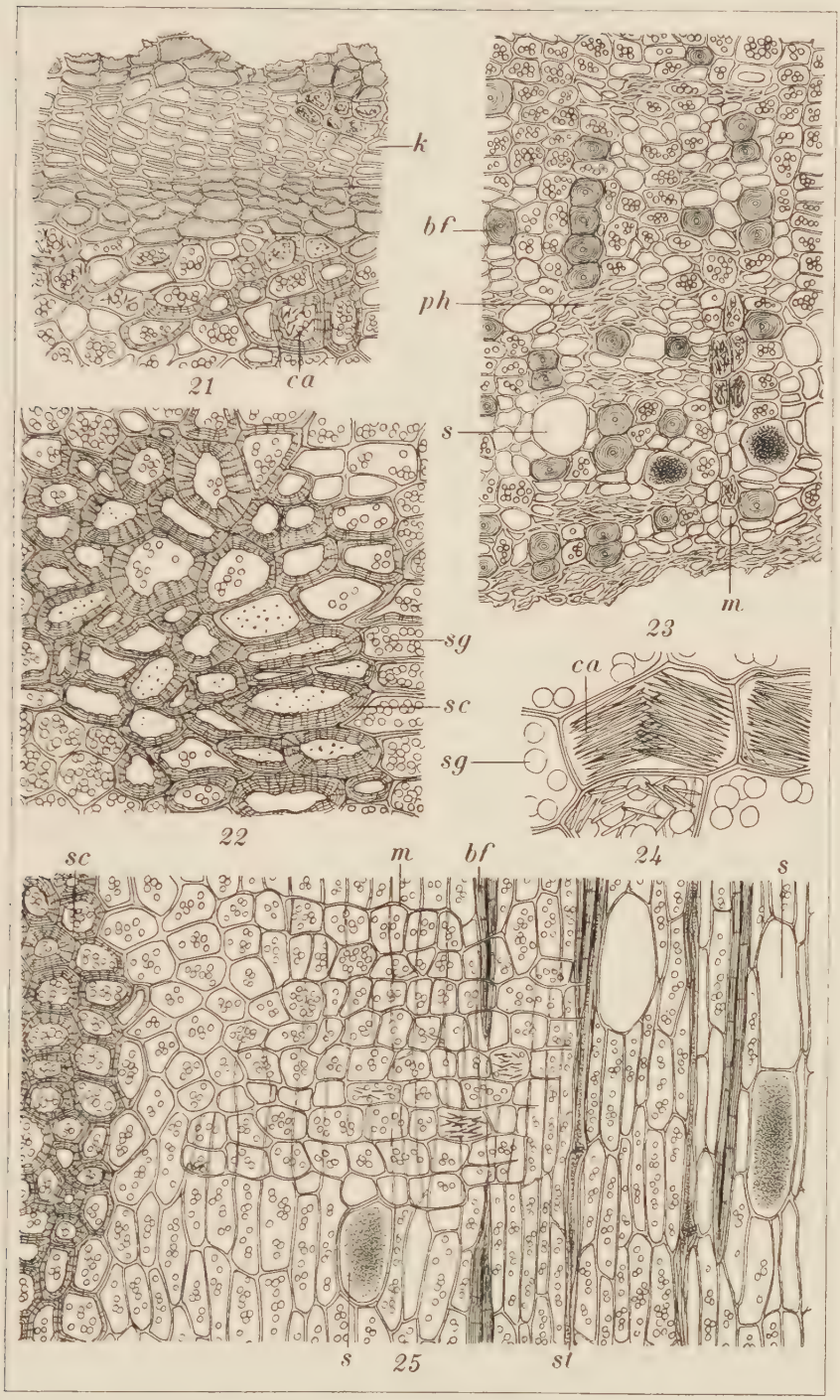

PLATE 6. CINNAMOMUM CASSIA BLUME.

PLATE 7.—CINNAMOMUM CASSIA BLUME.

PLATE 8. CINNAMOMUM MINDANAENSE ELMER.

PLATE 9. CINNAMOMUM MINDANAENSE ELMER.

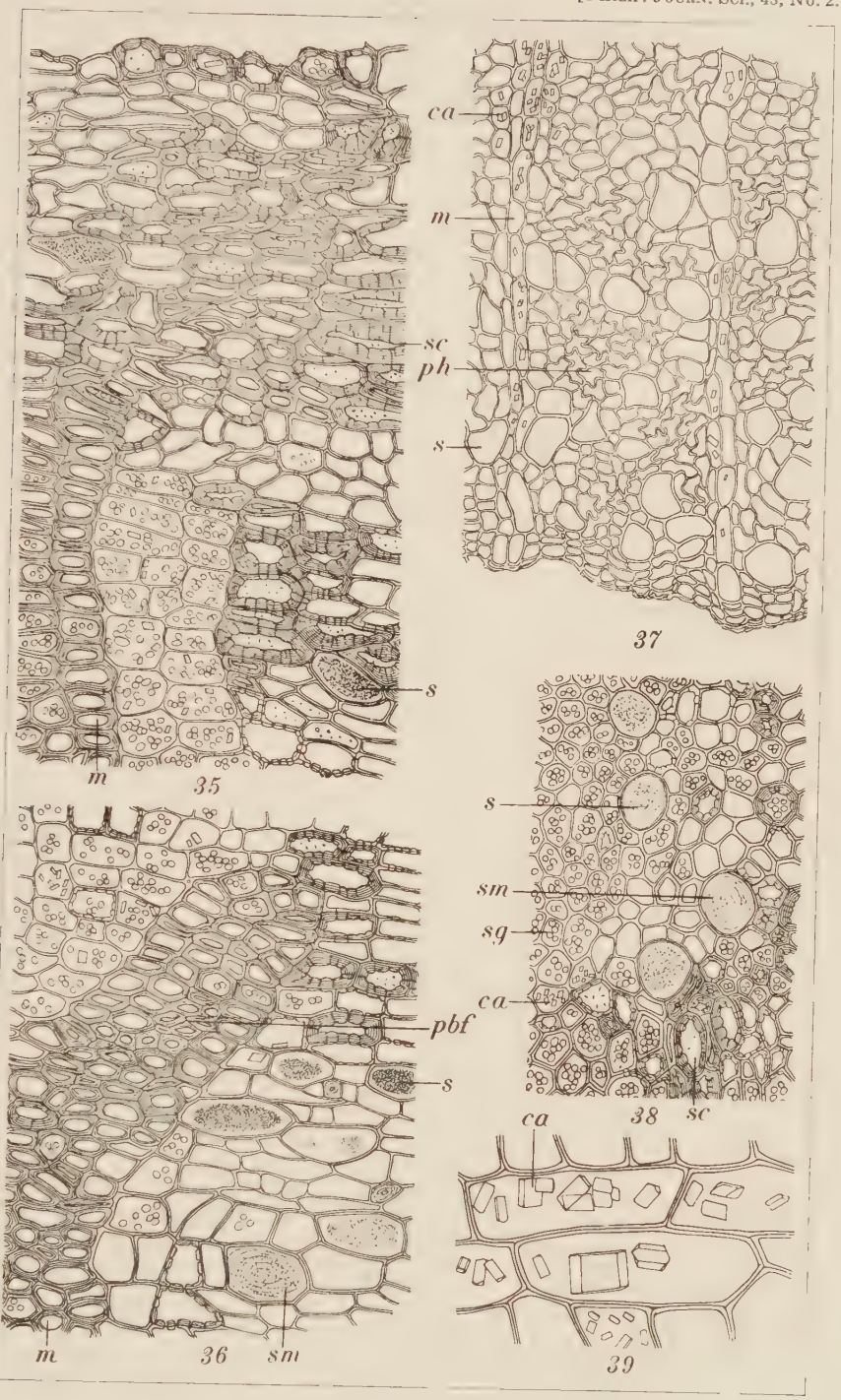

PLATE 10. CINNAMOMUM MINDANAENSE ELMER.

PLATE 11. CINNAMOMUM MINDANAENSE ELMER.

PLATE 12. CINNAMOMUN MERCADOI VIDAL.

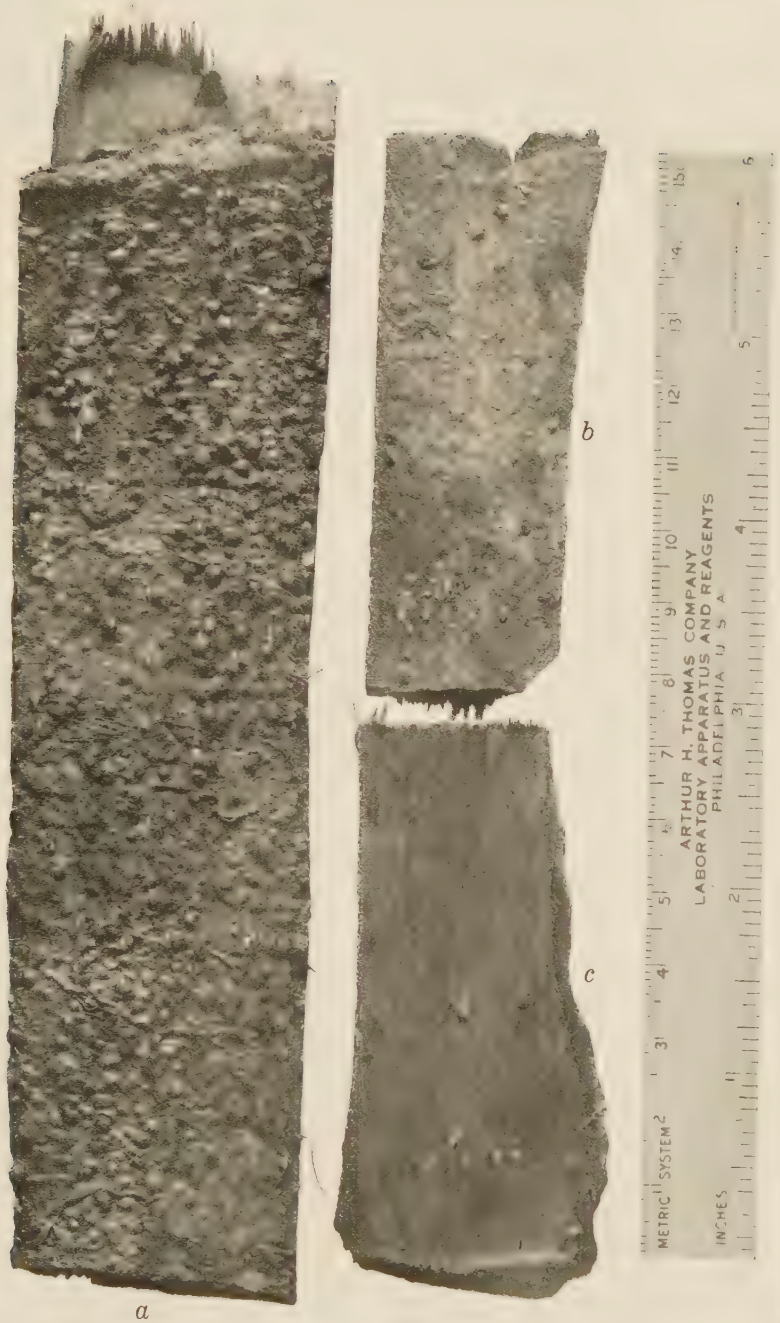

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PLATE 13. CINNAMOMUM MERCADOI VIDAL.

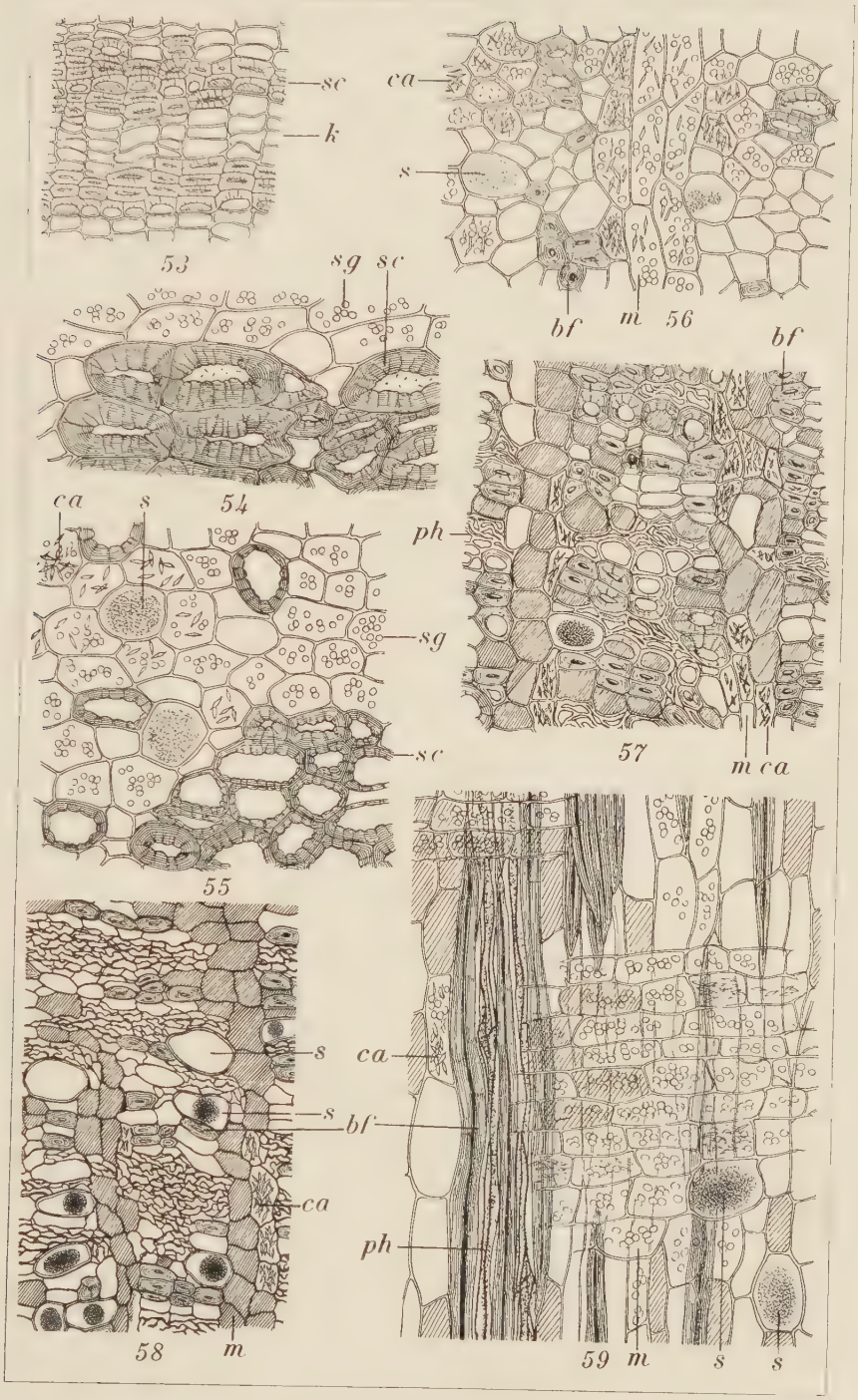

PLATE 14. CINNAMOMUM MERCADOI VIDAL.

PLATE 15. CINNAMOMUM MERCADOI VIDAL.

PLATE 16. CINNAMOMUM INERS REINWARDT.

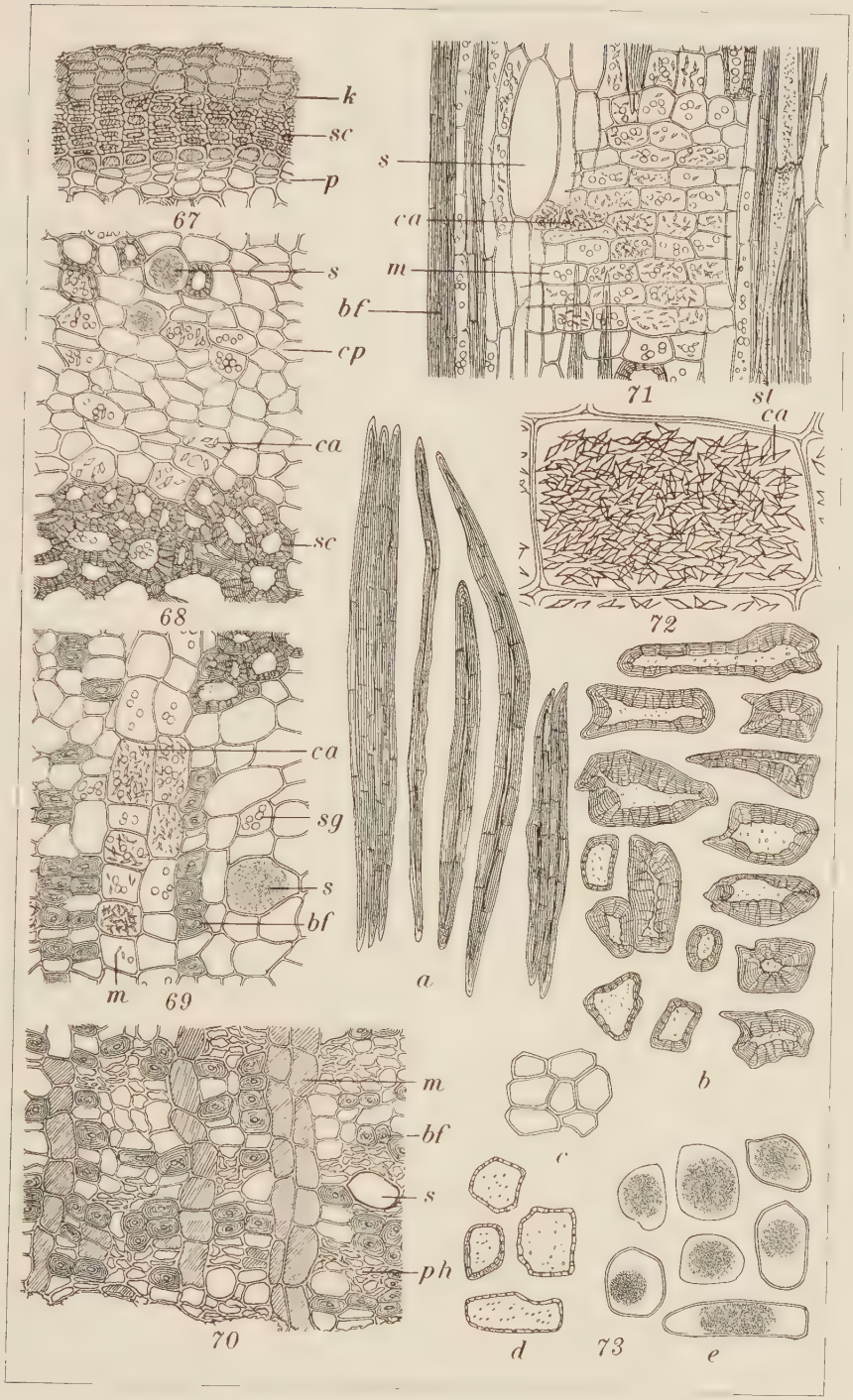

PLATE 17. CINNAMOMUM INERS REINWARDT.

PLATE 18. CINNAMOMUM BURMANNI BLUME.

PLATE 19. CINNAMOMUM INERS REINWARDT AND CINNAMOMUM BURMANNI BLUME.

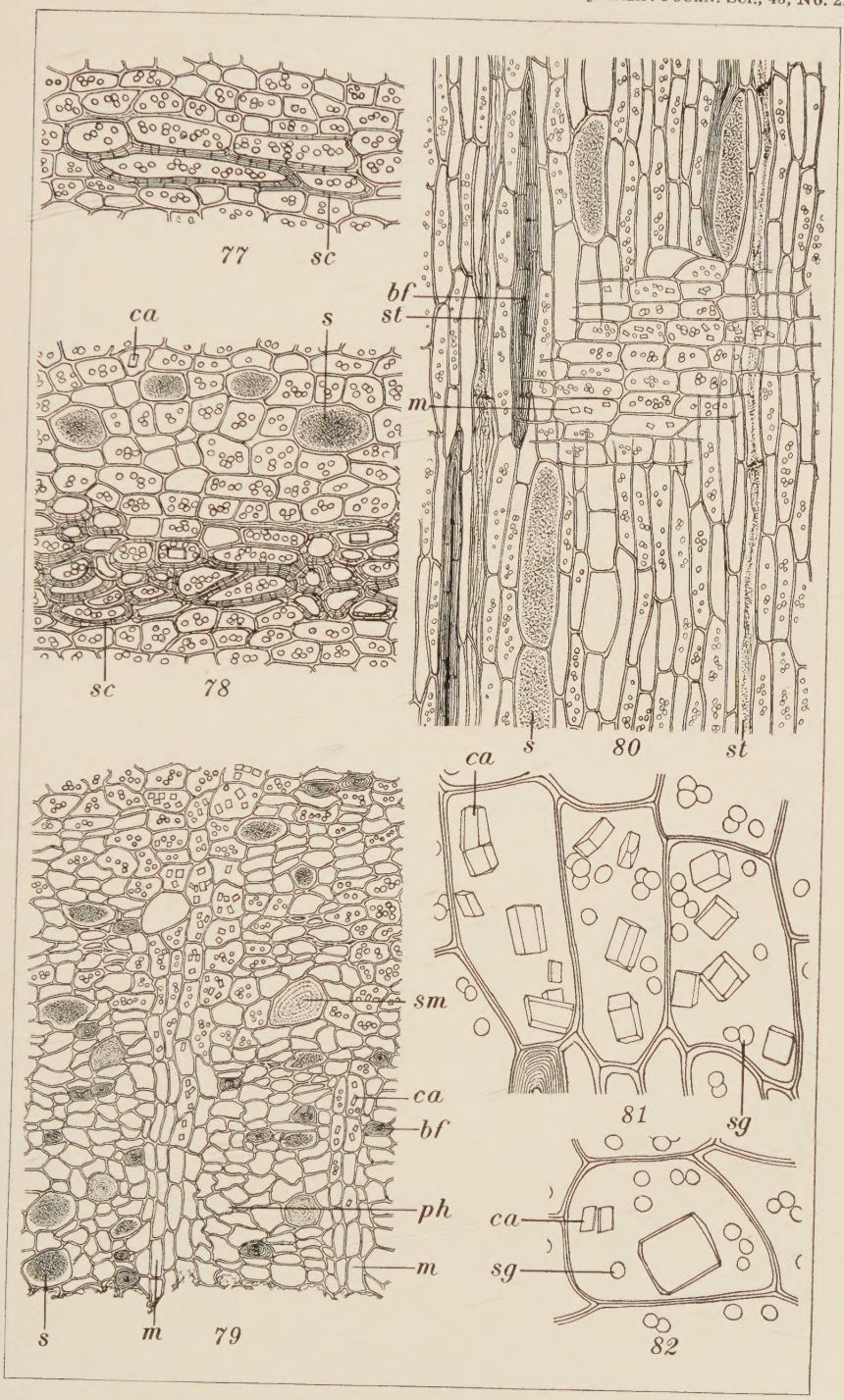

PLATE 20. CINNAMOMUM BURMANNI BLUME.

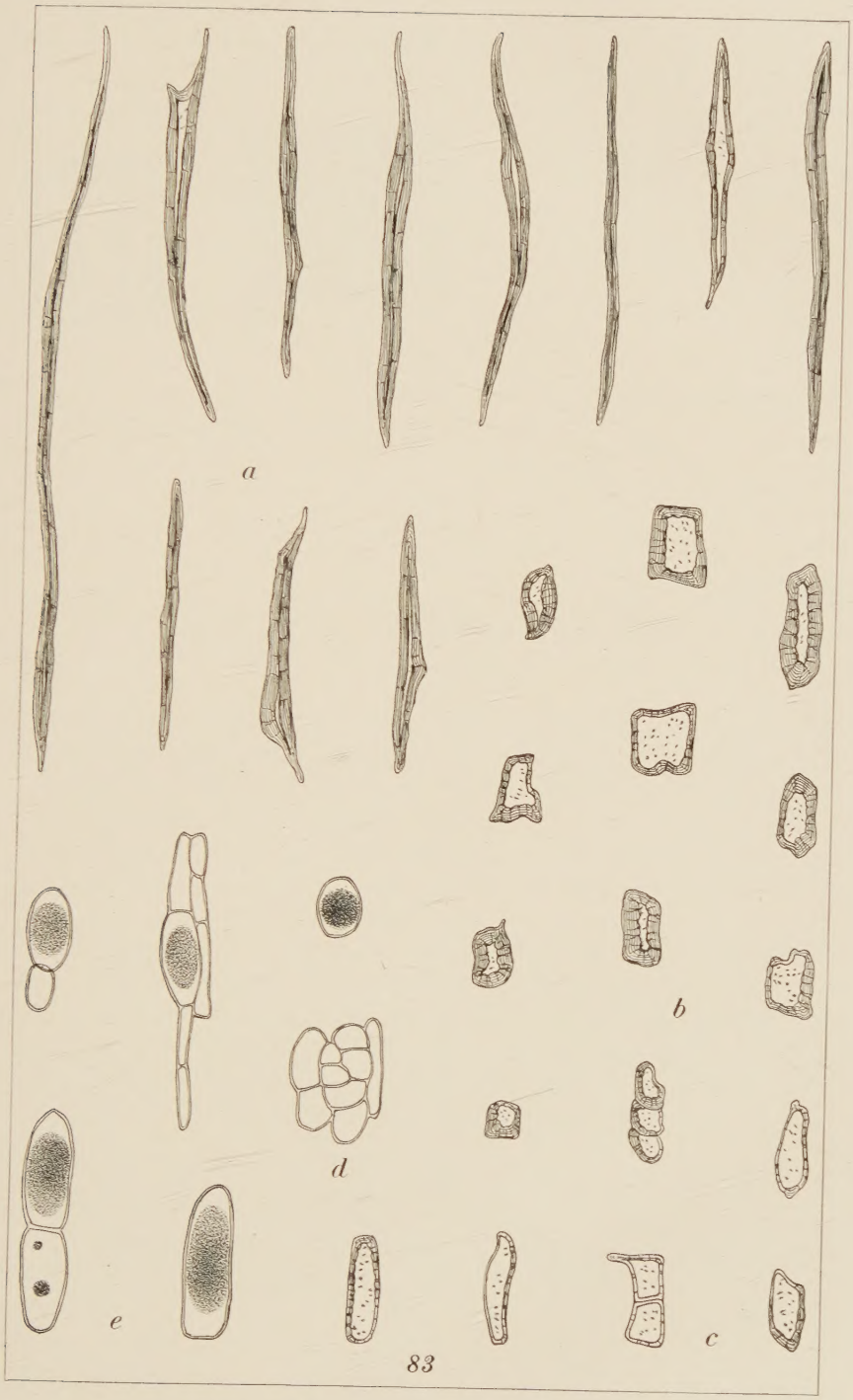

PLATE 21. CINNAMOMUM BURMANNI BLUME.